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RESEARCH METHODOLOGY

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SYLLABI-BOOK MAPPING TABLE

Research Methodology

Syllabi	Mapping in Book
BLOCK - I: RESEARCH PROPOSAL **UNIT 1:** Research: Meaning of Research; Types of Research - Exploratory Research, Conclusive Research; The Process of Research; Research Applications in Social and Business Sciences; Features of a Good Research Study.	**Unit 1:** Introduction to Research **(Pages 1-15)**
UNIT 2: Research Problem and Formulation of Research Hypotheses: Defining the Research Problem; Management Decision Problem Vs Management Research Problem; Problem Identification Process; Components of the Research Problem; Formulating the Research Hypothesis - Types of Research Hypothesis; Writing a Research Proposal - Contents of a Research Proposal and Types of Research Proposals.	**Unit 2:** Research Problem and Formulation of the Research Hypotheses **(Pages 16-34)**
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BLOCK - III: METHODOLOGY **UNIT 5:** Attitude Measurement and Scaling: Types of Measurement Scales; Attitude; Classification of Scales: Single Item Vs Multiple Item Scale, Comparative Vs Non-Comparative Scales, Measurement Error, Criteria for Good Measurement.	**Unit 5:** Attitude Measurement and Scaling **(Pages 77-95)**
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INTRODUCTION

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Research simply means a search for facts – answer to questions and solutions to problems. It is a purposive investigation. It is an organized inquiry. It seeks to find explanations to unexplained phenomena to clarify doubtful facts and to correct the misconceived notions.

Research is a scientific endeavour and involves the scientific method. The scientific method is a systematic step-by-step procedure following the logical processes of reasoning. Scientific method is a means for gaining knowledge of the universe. It does not belong to any particular body of knowledge; it is universal. It does not refer to a field of specific subject of matter, but rather to a procedure or mode of investigation.

Research methodology refers to the procedures used in making systematic observations or otherwise obtaining data, evidence, or information as part of a research project or study. It defines what the activity of research is, how to proceed, how to measure progress, and what constitutes success.

This book, *Research Methodology*, is written with the distance learning student in mind. It is presented in a user-friendly format using a clear, lucid language. Each unit contains an Introduction and a list of Objectives to prepare the student for what to expect in the text. At the end of each unit are a Summary and a list of Key Words, to aid in recollection of concepts learnt. All units contain Self-Assessment Questions and Exercises, and strategically placed Check Your Progress questions so the student can keep track of what has been discussed.

BLOCK - I
RESEARCH PROPOSAL

NOTES

UNIT 1 INTRODUCTION TO RESEARCH

Structure

1.0 INTRODUCTION

You might have watched on TV the panel discussion that takes place before the start of the cricket match. The facilitator asks the panel members questions like:

- Which side will win the match today?
- Will Sachin Tendulkar score a century?
- What will be the score that the batting side will pile?

You have noted that to answer these questions, the panel members quote factors such as the following:

- The outcome of previous instances when the two sides met and the winning streak of the teams at the venue
- The number of centuries Tendulkar has scored on a particular ground and against the opposite side
- Weather conditions, etc.

What the panel members are doing is that they are using the existing evidence or data systematically to make match predictions. In other words, we could say that they are using research methodology to answer the questions.

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Research methodology refers to the procedures used in making systematic observations or otherwise obtaining data, evidence, or information as part of a research project or study. It defines what the activity of research is, how to proceed, how to measure progress, and what constitutes success. We will study more about the various aspects of research methodology in the unit. First, let us understand what research is.

Research helps in decision making, especially in business. Effective decisions lead to managerial success, and this requires reducing the element of risk and uncertainty. For example, let us say, an ice-cream company has come up with a new flavour of ice-cream, which is a mixture of mango and vanilla. They are thinking of two names –'*Aam Masti*' or '*Mango Mania*'. They would like to sell the ice-cream to children and are not sure which name has more appeal. One of the ways in which this can be done is by using the scientific method of enquiry and following a structured approach to collect and analyse information and then eventually subject it to the manager's judgement. This is no magic mantra but a scientific and structured tool available to every manager, namely, research. Thus, research refers to a wide range activities involving a search for information, which is used in various disciplines.

Research activities may range from a simple collection of facts (example, the number of MBA students who opt for higher studies abroad in a particular institute) to validation of information (for example, is the new diet cola more popular among women?) to an exhaustive theory and model construction (for example, constructing a model of India's weather patterns in 2050 based on climate change projections).

In this unit, we will discuss the meaning of research, the types of researches available to the researcher and the process of a research study. We will also discuss the application of research in different areas of management and describe the features of a good research study.

1.1 OBJECTIVES

After going through this unit, you will be able to:

- Define the concept of research in management
- Identify the types of researches available to a business researcher
- Describe the complete process of a research study
- Explain the application of research in different domains of Management
- Identify the criteria needed to classify research as meaningful and 'good' research

1.2 MEANING OF RESEARCH

Different scholars have interpreted the term 'research' in many ways. For instance, Fred Kerlinger (1986) stated that 'Scientific research is a systematic, controlled

and critical investigation of propositions about various phenomena.' Grinnell (1993) has simplified the debate and stated 'The word research is composed of two syllables, 're' and 'search'.

The dictionary defines the former as a prefix meaning 'again', 'anew' or 'over again'. Search is defined as a verb meaning 'to examine closely and carefully', 'to test and try', or 'to probe'. Together, they form a noun describing a careful, systematic, patient study and investigation in some field of knowledge, undertaken to establish facts or principles.'

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Thus, drawing from the common threads of the above definitions, we derive that *management research is an unbiased, structured, and sequential method of enquiry, directed towards a clear implicit or explicit business objective.* This enquiry might lead to proving existing theorems and models or arriving at new theories and models. Let us now understand each part of the definition.

The most important and difficult task of a researcher is to be as objective and neutral as possible. Even though the researcher might have a lot of knowledge about the topic, he/she must not try to deliberately get results in the direction of the hypotheses.

The second thing to be remembered is that you follow a structured and sequential method of enquiry. For example, you may want to look at what are the options that you can choose if you study abroad. And you search the internet and ask your relatives and friends about what are the options for studying abroad. This is search and not research. For research, there must be a structured approach that you need to follow, and then only will it be called scientific. Thus, you may do a background analysis of how many students go abroad to study and based on this, form a hypotheses that 80 per cent of young Indians go to universities in the USA for further study. Then, you conduct a small survey amongst the students who are intending to go abroad for study. And based on the data collected, you are able to prove or disprove the hypotheses. So, we can state that you had conducted a research study. You will study the process of research later in the Unit.

The last and most important aspect of our definition that needs to be carefully considered is the decision-assisting nature of business research. As Easterby-Smith, *et al.* (2002) state, business research must have some practical consequences, either immediately, when it is conducted for solving an immediate business problem or when the theory or model developed can be implemented and tested in a business setting. The world of business demands that managers and researchers work towards a goal—whether immediate or futuristic, else the research loses its significance in the field of management. The advantage with doing research is that one is able to take a decision with more confidence as one has tested it through research. For example, if you conduct a study of young women professionals and see that they have a need for a night crèche facility when they need to go out of town on official duty. You can conduct a small research to test what facilities they would like in this crèche and how much would they be willing to pay for this facility.

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In fact, it would not be wrong to say that without the tool of research there would be no new business practices or methods, as no one would want to start something new (for example, launch a new product, enter a new market segment, etc) without testing it through research.

Check Your Progress

1. State the most important and difficult task of a researcher.
2. What method of enquiry is required in research?

1.3 TYPES OF RESEARCH

Though every research conducted is unique, it is possible to categorize the research approach that you may decide to take. Figure 1.1 summarizes the types of research.

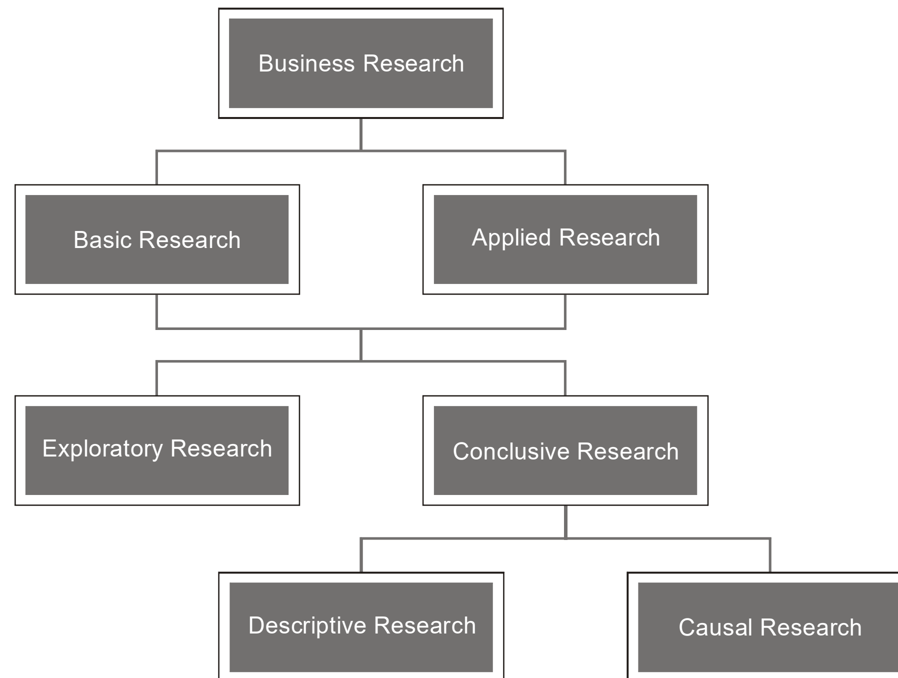


Fig. 1.1 *Types of Research*

Sometimes, research may be done for a purely academic reason of a need to know. For example, studies on employee dissatisfaction and attrition led to the study of impact of fixed working hours on family life and responsibilities. This study led to the organizations realizing that they need to have flexible woring hours so that employees can better manage their work-life balance. The context of this kind of study is vast and time period, flexible. This type of research is termed as ***fundamental*** or ***basic*** research. On the other hand, you have studies that are specific to a particular business decision. For example, you find that despite being such an affordable car the Tata Nano does not find a large number of buyers.

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Thus, the study you undertake would be of practical value to the specific organization. Secondly, it has implications for immediate action. This action-oriented research is termed as ***applied*** research.

However, now we would like to advise you not to look at the two as opposites of each other. It may happen that the research which started as applied might lead to some fundamental and basic research, which expands the body of knowledge or vice versa. The process followed in both basic and applied research is systematic and scientific; the difference between them could simply be a matter of context and purpose.

Research studies can also be classified based on the nature of enquiry or objectives. Based on the nature of enquiry or objectives, research can be of the following types.

- Exploratory research
- Conclusive research

1.3.1 Exploratory Research

As the name suggests, exploratory research is used to gain a deeper understanding of the issue or problem that is troubling the decision maker. The idea is to provide direction to subsequent and more structured and rigorous research. The following are some examples of exploratory research:

- Let us say a diet food company wants to find out what kind of snacks customers like to eat and where they generally buy health food from.
- A reality show producer wants to make a show for children. He would like to know what kind of shows children like to watch.
- There is an investment bank that would like to know from its customers about what kind of help they want from the bank while making their investments.

As can be seen, for the examples above an informal exploratory study would be needed.Exploratory research studies are less structured, more flexible in approach and sometimes could lead to some testable hypotheses. Exploratory studies are also conducted to develop the research questionnaire. (These will be discussed in detail in Unit 3.) The nature of the study being loosely structured means the researcher's skill in observing and recording all possible information will increase the accuracy of the findings.

1.3.2 Conclusive Research

Conclusive research is carried out to test and validate the study hypotheses. In contrast to exploratory research, these studies are more structured and definite. The variables and constructs in the research are clearly defined. For example, finding customer satisfaction levels of heavy consumers of different pizzas in the Pizza Hut menu. Now, this needs clear definition of customer satisfaction; secondly, how we will identify heavy consumers. The timeframe of the study and respondent

selection are more formal and representative. The emphasis on reliability and validity of the research findings are all the more significant, as the results might need to be implemented.

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Based on the nature of investigation required, conclusive research can further be divided into the following types:

- Descriptive research
- Causal research

Descriptive research

The main goal of descriptive research is to describe the data and characteristics about what is being studied. The annual census carried out by the Government of India is an example of descriptive research. The census describes the number of people living in a particular area. It also gives other related data about them. It is contemporary and time-bound. Some more examples of descriptive research are as follows:

- A study to distinguish between the characteristics of the customers who buy normal petrol and those who buy premium petrol.
- A study to find out the level of involvement of middle level versus senior level managers in a company's stock-related decisions
- As study on the organizational climate in different organizations.

All the above research studies are conducted to test specific hypotheses and trends. For example we might hypotheses that the level of involvement of senior level managers is higher than middle level managers in stock-related decisions. They are more structured and require a formal, specific and systematic approach to sampling, collecting information and testing the data to verify the research hypotheses.

Causal research

Causal research studies explore the effect of one thing on another and more specifically, the effect of one variable on another. For example, if a fast-food outlet currently sells vegetarian fare, what will be the impact on sales if the price of the vegetarian food is increased by 10 per cent. Causal research studies are highly structured and require a rigid sequential approach to sampling, data collection and data analysis. This kind of research, like research in pure sciences, requires experimentation to establish causality. In majority of the situations, it is quantitative in nature and requires statistical testing of the information collected.

Other types of research

- **Diagnostic research:** It is just like descriptive research but with a different focus. It is aimed towards in depth approaches to reach the basic casual relations of a problem and possible solutions for it. Prior knowledge of the

problem is required for this type of research. Problem formulation, defining the population correctly for study purposes, proper methods for collecting accurate information, correct measurement of variables, statistical analysis and tests of significance are essential in diagnostic research.

- **Historical:** Historical research studies the social effects of the past that may have given rise to current situations, i.e., past incidents are used to analyse the present as well as the future conditions. The study of the current state of Indian labour based on past labour union movements in the Indian economy to formulate the Indian Labour Policy is an example of this type of research.
- **Formulative:** It helps examine a problem with suitable hypothesis. This research, on social science, is mainly significant for clarifying concepts and innovations for further researches. The researchers are mainly concerned with the principles of developing hypothesis and testing with statistical tools.
- **Experimental:** The experimental type of research enables a person to calculate the findings, employ the statistical and mathematical devices and measure the results thus quantified.
- **Ex post facto:** This type of research is the same as experimental research, which is conducted to deal with the situations that occur in or around an organization. Examples of such a research are market failure of an organization's product being researched later and research into the causes for a landslide in the country.
- **Case study:** This method undertakes intensive research that requires a thorough study of a particular chapter.
- **Cross-sectional Research:** This type of research is undertaken after data is gathered once, during a period of days, weeks or months. Many cross-sectional studies are exploratory or descriptive in purpose. They are designed to look at how things are now, without any sense of whether there is a history or trend at work.
- **Action research:** It refers to research that improves the quality of action in the social world.
- **Policy-Oriented Research:** Reports employing this type of research focus on the question 'How can problem 'X' be solved or prevented?'

Check Your Progress

3. Which type of researched is especially carried out to test and validate the study hypotheses?
4. Census is an example of which type of research?

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1.4 THE PROCESS OF RESEARCH

While conducting research, information is gathered through a sound and scientific research process. Each year, organizations spend enormous amounts of money on research and development in order to maintain their competitive edge. Thus we propose a broad framework that can be easily be followed in most researches. The process of research is interlinked at every stage as shown in Figure 1.2.

Figure 1.2 illustrates a model research process.

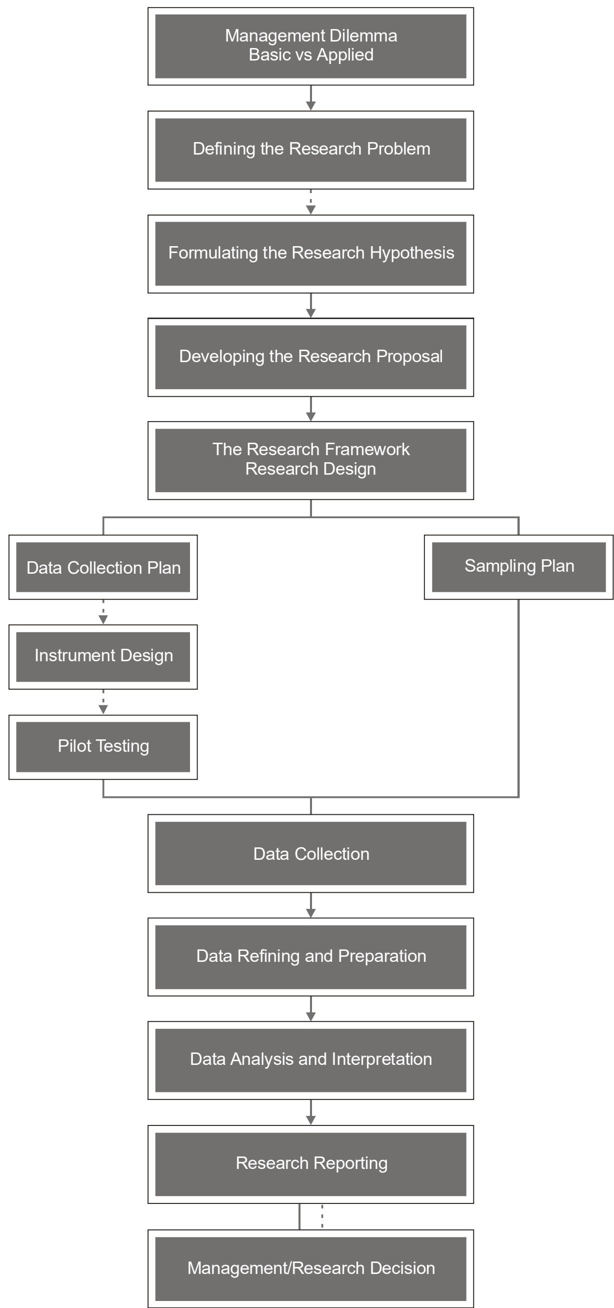


Fig. 1.2 *The Process of Research*

In the following paragraphs we will briefly discuss the steps that, in general, any research study might follow:

The management dilemma

Any research starts with the need and desire to know more. This is essentially the management dilemma. It could be the researcher himself or herself or it could be a business manager who gets the study by done by a researcher. The need might be purely academic (basic or fundamental research) or there might be an immediate business decision that requires an effective and workable solution (applied research).

Defining the research problem

This is the first and the most critical step of the research journey. For example, a soft drink manufacturer who is making and selling aerated drinks now wants to expand his business. He wants to know whether moving into bottled water would be a better idea or he should look at fruit juice based drinks. Thus, a comprehensive and detailed survey of the bottled water as well as the fruit juice market will have to be done. He will also have to decide whether he wants to know consumer acceptance of a new drink. Thus, there has to be complete clarity in the mind of the researcher regarding the information he must collect.

Formulating the research hypotheses

In the model, we have drawn broken lines to link defining the research problem stage to the hypotheses formulation stage. The reason is that every research study might not always begin with a hypothesis; in fact, the task of the study might be to collect detailed data that might lead to, at the end of the study, some indicative hypotheses to be tested in subsequent research. For example, while studying the lifestyle and eating-out behavior of consumers at Pizza Hut, one may find that the young student group consume more pizzas. This may lead to a hypotheses that young consumers consume more pizzas than older consumers.

Hypothesis is, in fact, the assumptions about the expected results of the research. For example, in the above example of work-life balance among women professionals, we might start with a hypothesis that higher the work-family conflict, higher is the intention to leave the job. We will discuss the conversion of the defined problem into working hypotheses in Unit 2.

Developing the research proposal

Once the management dilemma has been converted into a defined problem and a working hypothesis, the next step is to develop a plan of investigation. This is called the research proposal. The reason for its placement before the other stages is that before you begin the actual research study in order to answer the research question you need to spell out the research problem, the scope and the objectives of the study and the operational plan for achieving this. The proposal is a flexible

contract about the proposed methodology and once it is made and accepted, the research is ready to begin. The formulation of a research proposal, its types and purpose will be explained in the next unit.

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Research design formulation

Based on the orientation of the research, i.e., exploratory, descriptive or causal, the researcher has a number of techniques for addressing the stated objectives. These are termed in research as research designs. The main task of the design is to explain how the research problem will be investigated. There are different kinds of designs available to you while doing a research. These will be discussed in detail in Unit 3.

Sampling design

It is not always possible to study the entire population. Thus, one goes about studying a small and representative sub-group of the population. This sub-group is referred to as the sample of the study. There are different techniques available for selecting the group based on certain assumptions. The most important criteria for this selection would be the representativeness of the sample selected from the population under study.

Two categories of sampling designs available to the researcher are probability and non-probability. In the probability sampling designs, the population under study is finite and one can calculate the probability of a person being selected. On the other hand, in non-probability designs one cannot calculate the probability of selection. The selection of one or the other depends on the nature of the research, degree of accuracy required (the probability sampling techniques reveal more accurate results) and the time and financial resources available for the research. Another important decision the researcher needs to take is to determine the best sample size to be selected in order to obtain results that can be considered as representative of the population under study. We will learn more about this in unit 7.

Planning and collecting the data for research

In the model (Figure 1.2), we have placed planning and collecting data for research as proceeding simultaneously with the sampling plan. The reason for this is that the sampling plan helps in identifying the group to be studied and the data collection plan helps in obtaining information from the specified population. The data collection methods may be classified into secondary and primary data methods. Primary data is original and collected first hand for the problem under study. There are a number of primary data methods available to the researcher like interviews, focus group discussions, personal/telephonic interviews/mail surveys and questionnaires.

Secondary data is information that has been collected and compiled earlier for some other problem or purpose. For example, company records, magazine articles, expert opinion surveys, sales records, customer feedback, government

data and previous researches done on the topic of interest. This step in the research process requires careful and rigorous quality checks to ensure the reliability and validity of the data collected.

Data refining and preparation for analysis

Once the data is collected, it must be refined and processed in order to answer the research question(s) and test the formulated hypotheses (if any). This stage requires editing of the data for any omissions and irregularities. Then it is coded and tabulated in a manner in which it can be subjected to statistical testing. In case of data that is subjective and qualitative, the information collected has to be post coded i.e. after the data has been collected.

Data analysis and interpretation of findings

This stage requires selecting the analytical tools for testing the obtained information. There are a number of statistical techniques available to the researcher—frequency analysis, percentages, arithmetic mean, t-test and chi-square analysis. These will be explained in the later units.

Once the data has been analysed and summarized, linking the results with the research objectives and stating clearly the implications of the study is the most important task of the researcher.

The research report and implications for the manager's dilemma

The report preparation, from the problem formulation to the interpretation, is the final part of the research process. As we stated earlier, business research is directed towards answering the question 'what are the implications for the corporate world?' Thus, in this step, the researcher's expertise in analysing, interpreting and recommending, is very important. This report has to give complete details about everything that was done right from problem formulation, to the methodology followed to the conclusions inding of the study. The nature of the report may be different depending on whether it is meant for a business person or is an academic report. This will be discussed in detail in Unit 13.

Check Your Progress

5. What is another name for the process of 'developing a plan of investigation'?
6. List some of the primary data methods available to the researcher.

1.5 RESEARCH APPLICATIONS IN SOCIAL AND BUSINESS SCIENCES

Research is a crucial element in the area of business. It helps the decision maker to identify new opportunities for business growth. Research provides information

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about various aspects of business, like product life cycle, consumer behaviour, market opportunities and threats, technological changes, social changes, economic changes, environmental changes, and so on, which are important for any decision maker to run the business smoothly.

Research is crucial in the following areas of business:

- **Marketing function** - Research is the lifeline in the field of marketing, where it is carried out on a vast array of topics and is conducted both in-house by the organization itself and outsourced to external agencies. This could be related to the 4 Ps- product, price, place and promotions.
- **Personnel and human resource management** - Human resources (HR) and organizational behaviour is an area which involves basic or fundamental research as a lot of academic, macro-level research may be adapted and implemented by organizations into their policies and programmes.
- **Financial and accounting research** - The area of financial and accounting research is quite vast and includes asset pricing, corporate finance and capital markets, market-based accounting research, modelling and forecasting in volatility, risk, etc.
- **Production and operations management** - This area of management is one in which research results are implemented, taking on huge cost and process implications. Research in this area relates to operation planning, demand forecasting, process planning, project management, supply chain management, quality assurance and management.

Research in social science includes an in-depth study and evaluation of human behavior by using scientific methods in either quantitative or qualitative manner. As social science is concerned with the study of society and human behavior, it is important for a business organization in terms of understanding their customers, their taste, needs, preferences, lifestyle and their behaviour. New products or services are unlikely to succeed without proper consumer studies and survey.

1.6 FEATURES OF A GOOD RESEARCH STUDY

In the above sections we learnt that research studies can vary from the loosely structured method based on observations and impressions to the strictly scientific and quantifiable methods. However, for a research to be of value, it must possess the following characteristics:

(a) It must have a clearly stated purpose. This not only refers to the objective of the study, but also precise definition of the scope and domain of the study.

(b) It must follow a systematic and detailed plan for investigating the research problem. The systematic conduction also requires that all the steps in the research process are interlinked and follow a sequence.

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(c) The selection of techniques of collecting information, sampling plans and data analysis techniques must be supported by a logical justification about why the methods were selected.

(d) The results of the study must be presented in an unbiased, objective and neutral manner.

(e) The research at every stage and at any cost must maintain the highest ethical standards.

(f) And lastly, the reason for a structured, ethical, justifiable and objective approach is the fact that the research carried out by you must be replicable. This means that the process followed by you must be 'reliable', i.e., in case the study is carried out under similar conditions it should be able to reveal similar results.

Check Your Progress

7. What are demand forecasting, and quality assurance and management a part of?
8. What does the replicability of a research mean?

1.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The most important and difficult task of a researcher is to be as objective and neutral as possible.
2. Research always requires a structured and sequential method of enquiry.
3. Conclusive research is especially carried out to test and validate the study hypotheses.
4. Census is an example of descriptive research.
5. Research proposal is another name for the process of 'developing a plan of investigation.'
6. Some of the primary data methods available to the researcher include interviews, focus group discussions, personal/telephonic interviews/mail surveys and questionnaires.
7. The demand forecasting, and quality assurance and management are a part of production and operations management.
8. The replicability of a research means that the process followed by you must be 'reliable', i.e., in case the study is carried out under similar conditions it should be able to reveal similar results.

1.8 SUMMARY

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- Research is a tool, of special significance in all areas of management. It can be defined as an unbiased, structured, and sequential method of enquiry, directed towards a clear implicit or explicit business objective. This enquiry might lead to proving existing postulates or arriving at new theories and models.
- Research may be done for a purely academic reason of a need to know (fundamental or basic research) or it could be undertaken as it would be of practical value to an organization with implications for immediate action (applied research).
- Based on the nature of enquiry or the objective, research can be exploratory or conclusive research.
- Conclusive research can be of two types—descriptive or causal studies.
- A research study usually follows a structured sequence of steps:
  - o Developing and defining the research problem
  - o Formulating the study hypothesis
  - o Developing the study plan or proposal
  - o Identifying the research design
  - o Designing the sampling approach
  - o Conceptualizing and developing the data collection plan
  - o Executing data analysis
  - o Working out data inference and conclusions
  - o Compiling and preparing the research report
- Different kinds of studies are carried out in the area of business management such as marketing, finance, human resources and operations. Each having their own orientation and approach.
- For a research to be recognized as significant, it must follow some basic criteria – clearly stated purpose; a systematic and detailed plan; logical justification for the selection of techniques of collecting information, sampling plans and data analysis techniques; unbiased, objective and neutral results; ethical standards; sequential and replicable.

1.9 KEY WORDS

- **Applied research**: Studies that are related to specific problems and are conducted to find solutions.
- **Basic research**: Studies that are conducted for academic reasons and do not have immediate applicability.

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- **Causal research**: These studies need experimentation and study the cause and effect relationship.
- **Conclusive research**: More structured studies conducted to test or validate the study hypotheses.
- **Descriptive research**: Conclusive studies that describe the phenomena, group or situation under study.
- **Exploratory research**: Loosely structured studies carried to gain a deeper understanding about something.
- **Hypothesis:** A tentative assumption made in order to draw out and test its logical or empirical consequences; the assumptions about the expected results of a research.
- **Postulate:** Something taken as true or factual and used as the starting point for a course of action.

1.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. How would you define business research? Illustrate with examples.
2. Distinguish between descriptive and causal research studies.
3. What are the features of a good research study?

Long-Answer Questions

1. What are the different types of researches that can be conducted by a researcher?
2. Describe in detail the steps to be carried out in a typical research study.
3. Can research be carried out in all areas of business? Explain with examples about the kind of studies that can be done.

1.11 FURTHER READINGS

Chawla D and Sondhi N. 2016. *Research Methodology: Concepts and Cases*, 2nd edition. New Delhi: Vikas Publishing House.

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UNIT 2 RESEARCH PROBLEM AND FORMULATION OF THE RESEARCH HYPOTHESES

Structure

2.0 INTRODUCTION

In the last unit, you were introduced to the meaning of research as well its types, process and features. In this unit, we will focus on the research problem and the formulation of the research hypothesis. The most important aspect of the business research method is to identify the 'what', i.e., what is the exact research question to which you are seeking an answer. The second important thing is that the process of arriving at the question should be logical and follow a line of reasoning that can lend itself to scientific enquiry. This reasoning approach needs to be converted into a possible research question. And based on the initial study of the research topic, you should be able to make certain assumptions which can lend direction to the study as research hypotheses.

Thus in this unit, we will understand how to identify a problem that can be subjected to research and help us reduce decision risks. This will follow a structured and logical path to help us arrive at the research problem. Next. we will learn how to convert this research question into research hypotheses. The conduct of a research study usually requires that you write the steps you will take to do the study in the form of a proposal. We will end the unit by understanding how one writes a research proposal.

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2.1 OBJECTIVES

After going through this unit, you will be able to:

- Explain the business decision problem
- Translate the decision needs into clearly spelt research questions
- Describe the method to be followed to arrive at the research questions
- List the components of a research problem
- Translate the research questions into research hypotheses depending on the nature of research
- Prepare a research proposal

2.2 DEFINING THE RESEARCH PROBLEM

The challenge for a business manager is not only to identify and define the decision problem; the bigger challenge is to convert the decision into a research problem that can lead to a scientific enquiry. As Powers et al. (1985) have put it, 'Potential research questions may occur to us on a regular basis, but the process of formulating them in a meaningful way is not at all an easy task'. One needs to narrow down the decision problem and rephrase it into workable research questions.

Thus, the first and the most important step of the research process is like the start of a journey, in this instance the research journey, and the identification of the problem gives an indication of the expected result . A research problem can be defined as a gap or uncertainty in the decision makers' existing body of knowledge which inhibits efficient decision making. Sometimes it may so happen that there might be multiple alternative paths one can take and we will have to select which of these we would like to consider as the problem to be studied. As Kerlinger (1986) states, 'If one wants to solve a problem, one must generally know what the problem is. It can be said that a large part of the problem lies in knowing what one is trying to do.' The defined research problem might be classified as simple or complex. Simple problems are those that are easy to understand and the components and identified relationships are linear, e.g., the relationship between cigarette smoking and lung cancer. Complex problems on the other hand, deal with the interrelationship between multiple variables, e.g., the impact of social networking sites like Facebook and online shopping sites like Flipkart on consumer purchase behaviour in shops and markets. The impact might also further differ in terms of males and females. Other influencing factors on the buying behaviour could be a person's lifestyle, age and education. Complex problems such as these deal with multiple variables. Thus, they require a model or framework to be developed to define the research approach.

2.3 MANAGEMENT DECISION PROBLEM VS MANAGEMENT RESEARCH PROBLEM

The problem recognition process starts when the decision maker faces some difficulty or decision dilemma. Sometimes, this might be related to actual and immediate difficulties faced by the manager (applied research) or gaps experienced in the existing body of knowledge (basic research). The broad decision problem has to be narrowed down to information-oriented problem, which focuses on the data or information required to arrive at any meaningful conclusion. Given in Table 2.1 is a set of decision problems and the subsequent research problems that might address them. Please remember these are only indicative questions and there could be many more ways of arriving at an answer to the decision problem. Secondly, it is not essential that the decision maker will always go in for research as he may arrive at a decision without research also. Sometimes, the company might have so much experience in the business that they feel no additional information can be obtained through research. As stated earlier in Unit 1, research is conducted when the decision maker wants to reduce some risk and uncertainity while taking a decision.

Table 2.1 *Converting Management Decision Problem into Research Problem*

DECISION PROBLEM	RESEARCH PROBLEM*
1. What should be done to increase the consumers of organic food products in the domestic market?	1. What is the awareness and purchase intention of health conscious consumers for organic food products?
2. How to reduce turnover rates in the BPO sector?	2. What is the impact of shift duties on work exhaustion and turnover intentions of the BPO employees?
3. Can the housing and real estate growth be accelerated?	3. What is the current investment in real estate and housing? Can the demand in the sector be forecasted for the next six months?

* This requires you to follow a sequence of steps as specified in Figure 2.3

Thus, what we clearly see is that the management problem is a difficulty faced by the decision maker and by itself cannot be tested. To do this it must be stated in a form that can lend itself to a scientific enquiry. In case the decision maker is a business manager, the management research problem requires that we look for an answer to to the problem faced by the manager, as in the above example of how to reduce the turnover rate in a BPO company. This problem has to be translated to a simpler form of research question. And as said earlier, there can be more than one research problem that can help the manager in taking a decision. It depends on the researcher how he looks at it. For example, he may say that the research problem is:

- *What are the management policies in other BPO companies?*
- *Why do the employees leave the company? What is the problem area?*

- *Are the shift duties creating a problem of work family conflict which is why they leave?*
- *How can the company work on employee engagement so that he stays with the company?*

Thus, as you can see we can have many questions. Finally, the research problem you think is likely to give the possible solution is the one you decide to take as your research problem.

Check Your Progress

1. The management decision problem must be reduced to which type of problem?
2. Which type of relationships are tested under simple research problems?
3. Which type of problem is faced by the decision maker at the start of the problem recognition process?

2.4 PROBLEM IDENTIFICATION PROCESS

The process of identifying the research problem involves the following steps:

1. Management decision problem

The entire process begins with the identification of the difficulty encountered by the business manager/researcher. The manager might decide to conduct the study himself or gives it to a researcher or a research agency. Thus this step requires that there must be absolute clarity about what is the purpose of getting a study done. When the work is to be done by an outsider it is very important that discussion is held with the business manager.

2. Discussion with subject experts

The next step involves getting the problem in the right perspective through discussions with industry and subject experts. These individuals are knowledgeable about the industry as well as the organization. They could be found both within and outside the company. The information on the current and future is obtained with the assistance of an interview. Thus, the researcher must have a predetermined set of questions related to the doubts experienced in problem formulation. It should be remembered that the purpose of the interview is simply to gain clarity on the problem area and not to arrive at any kind of conclusions or solutions to the problem. For example, for the organic food study,that is mentioned in Table 2.1 as a decision problem, the researcher might decide to go to food experts like doctors and dieticians to seek their opinion. This data should, in practice, be supported with secondary data in the form of theory as well as organizational facts.

3. Review of existing literature

A literature review is a comprehensive collection of the information obtained from published and unpublished sources of data in the specific area of interest to the researcher. This may include journals, newspapers, magazines, reports, government publications, and also computerized databases. The advantage of the survey is that it provides different perspectives and methodologies to be used to investigate the problem, as well as identify possible variables that may be studied. Second, the survey might also show that our research problem has already been investigated and this might be useful in solving the decision dilemma. It also helps in narrowing the scope of the study into a research problem.

Once the data has been collected, the researcher must write it down in his/her own words and clearly show how this is linked to the research topic under study. The logical and theoretical framework developed on the basis of past studies should be able to provide the foundation for the problem statement.

The reporting should cite the author and the year of the study clearly. There are several internationally accepted forms of citing references and quoting from published sources. The *Publication Manual of the American Psychological Association* (sixth edition, 2009) and the *Chicago Manual of Style* (seventeenth edition, 2017) are academically accepted as referencing styles in management.

4. Organizational analysis

Another significant source for deriving the research problem is the industry and organizational data. In case the researcher/investigator is the manager himself/herself, the data might be easily available. This data needs to include the organizational demographics—origin and history of the firm; size, assets, nature of business, location and resources; management philosophy and policies as well as the detailed organizational structure, with the job descriptions. It is to be remembered here that the organizational data might not be always essential, for example in case of basic research, where the nature of study is not company specific but general.

5. Qualitative survey

Sometimes the expert interview, secondary data and organizational information might not be enough to define the problem. In such a case, a small exploratory qualitative survey can be done to understand the reason for some . For example, a soap like Dove may be very good in terms of price and quality but very few people in the smaller towns buy it. When we do a secondary data analysis, or talk to experts there seems to be no problem. Then we do a quick round of interview with women who come to a *kirana* store to find out why Dove is not bought. And the women tell us that the same soap is used by the whole family, and husband and

sons do not use Dove as they say this is a soap for women, which is the reason why dove is not bought by them. These surveys thus are done on small samples and might make use of focus group discussions or interviews with the respondent population to help uncover relevant and current issues which might have a significant bearing on the problem definition.

In the organic food research, focused group discussions with young and old consumers revealed the level of awareness about organic food and consumer sentiments related to purchase of more expensive but a healthy food product.

6. Management research problem

Once the audit process of secondary review and interviews and survey is over, the researcher is ready to focus and define the issues of concern, that need to be investigated further, in the form of an unambiguous and clearly defined research problem. Here, it is important to remember that simply using the word 'problem' does not mean that there is something wrong that has to be corrected, it simply indicates the gaps in information or knowledge base available to the researcher. These might be the reason for his inability to take the correct decision. Second, identifying all possible dimensions of the problem might be a monumental and impossible task for the researcher. For example, the lack of sales of a newly launched product could be due to consumer perceptions about the product, ineffective supply chain, gaps in the distribution network, competitor offerings or advertising ineffectiveness. It is the researcher who has to identify and then refine the most probable cause of the problem and formalize it as the research problem. This would be achieved through the five preliminary investigative steps indicated above. Once done the research problem has to be clearly defined in terms of certain components This will be discussed in the next section.

7. Theoretical foundation and model building

Having identified and defined the variables under study, the next step is to try and form a theoretical framework. It can be best understood as a schema or network of the probable relationship between the identified variables. An advantage of the model is that it clearly shows the expected direction of the relationships between the concepts. There is also an indication of whether the relationship would be positive or negative.

This step, however, is not mandatory as sometimes the objective of the research is to explore the probable variables that might explain the observed phenomena and the outcome of the study helps to finally develop a conceptual model.

Given below is a predictive model for turnover intentions developed to explain the high rate of attrition amongst BPO professionals. Once validated, it is of course possible to test it in different contexts and differing respondent population.

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The Turnover Intention Model

The proposed model to predict turnover intention is specified as mentioned below:

TI = f (WE, OC, A, MS, TWE) ...(1)

Where,
TI = Turnover intention
WE = Work exhaustion
OC = Organizational commitment
A = Age
MS = Marital status
TWE = Total work experience

The theoretical construct of work exhaustion is influenced by Perceived Workload (PWL), Fairness of Reward (FOR), Job Autonomy (JA) and Work Family Conflict (WFC) [*Adapted from Ahuja, Chudoba and Kacmar, 2007*]. This can be mathematically written as:

WE = f (PWL, FOR, JA, WFC) ...(2)

Similarly, Organizational Commitment depends upon Job Autonomy, Work–Family Conflict, Fairness of Reward and Work Exhaustion (WE) [Adapted from—Ahuja, Chudoba and Kacmar, 2007]. Therefore, this can be stated mathematically as

OC = f (JA, WFC, FOR, WE) ...(3)

The model is diagrammatically represented in Figure 2.2.

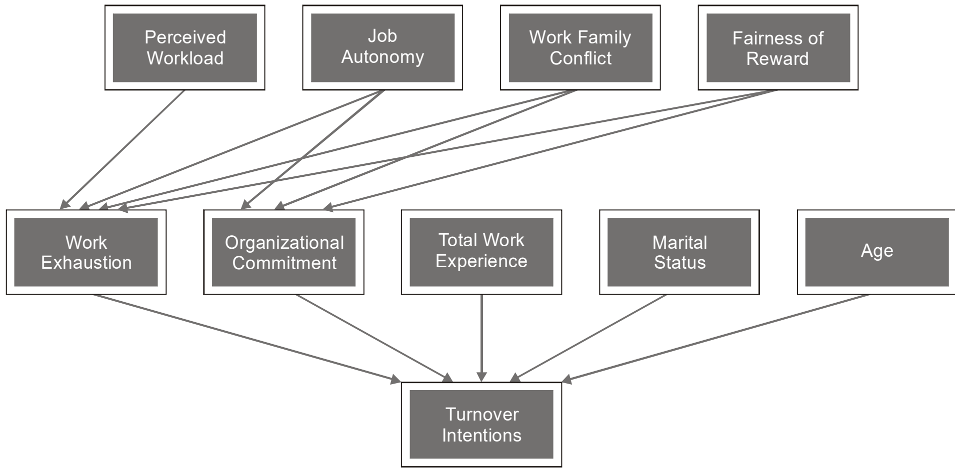


Fig. 2.2 *Proposed Model for Turnover Intention*

The formulated framework has been explained verbally as a ***verbal model.*** The flowchart of the relationship between variables has been demonstrated in graphical form as a ***graphical model*** and the same have been also reduced to three mathematical equations specifying the relationship between the same in the form of a ***mathematical model***. What needs to be understood is that all three are representatives of the same framework.

8. Statement of research objectives

Next, the research question(s) that were formulated need to be broken down as tasks or objectives that need to be met in order to answer the research question.

This section makes active use of verbs such as 'to find out', 'to determine', 'to establish', and 'to measure' so as to spell out the objectives of the study. In certain cases, the main objectives of the study might need to be broken down into sub-objectives which clearly state the tasks to be accomplished.

In the organic food research, the objectives and sub-objectives of the study were as follows:

1. **To study the existing organic market:**
    - To categorize the organic products available in Delhi into grain, snacks, herbs, pickles, squashes and fruits and vegetables;
    - To estimate the demand pattern of various products for each of the above categories;
    - To understand the marketing strategies adopted by different players for promoting and propagating organic products.
2. **Consumer diagnostic research:**
    - To study the existing consumer profile, i.e., perception and attitudes towards organic products and purchase and consumption patterns;
    - To study the potential customers in terms of consumer segments, level of awareness, perception and attitude towards health and organic products;
3. **Opinion survey:** To assess the awareness and opinions of experts such as doctors, dieticians and chefs in order to understand organic consumption.

Figure 2.3 summarizes the problem identification process.

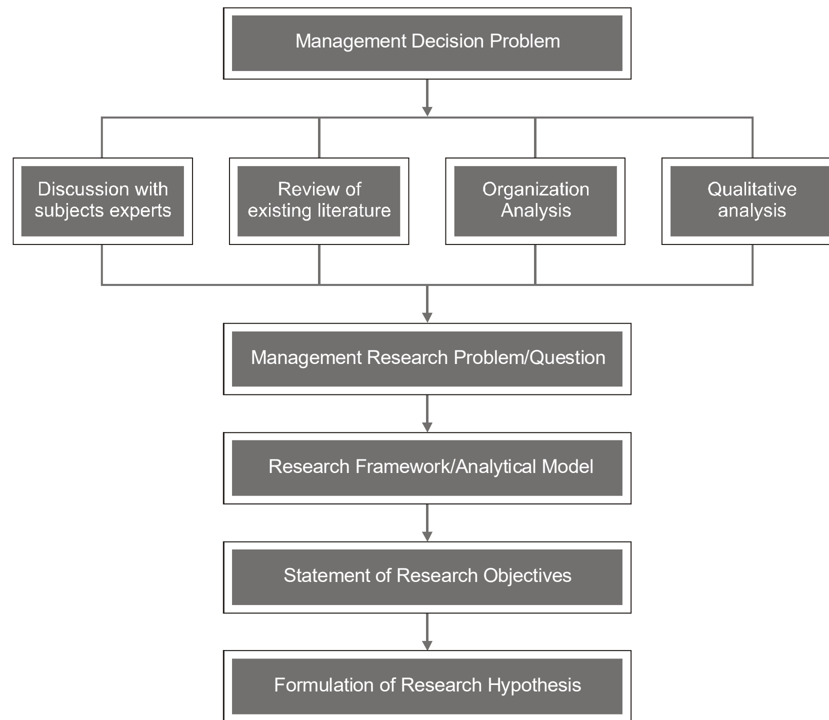


Fig. 2.3 *Problem Identification Process*

2.5 COMPONENTS OF THE RESEARCH PROBLEM

To address the problems of clarity and focus, we need to understand the components of a well defined problem. These are:

The unit of analysis

The researcher must specify in the problem statement the individual(s) from whom the research information is to be collected and on whom the research results are applicable. This could be the entire organization, departments, groups or individuals.

Research variables

The research problem also requires identification of the key variables under study. A variable is any concept that varies and we can assign numerals or values. A variable may be dichotomous in nature, that is, it can possess only two values such as male-female or customer–non-customer. Values that can only fit into prescribed number of categories are continuous variables, for example, very important (1) to very unimportant (5). There are still others that possess an indefinite set, e.g., age, income and production data.

Variables can be further classified into four categories, depending on the role they play in the problem under consideration. These are

- Independent variables
- Dependent variables
- Moderating variables
- Extraneous variables

- **Independent variable:** Any variable that can be stated as influencing or impacting the dependent variable is referred to as an independent variable (IV). More often than not, the task of the research study is to establish the relationship between the independent and the dependent variable(s).

  In the organic food study, the consumers' attitude towards healthy lifestyle could impact their organic purchase intention. Thus, attitude becomes the independent and intention the dependent variable. Another researcher might want to assess the impact of job autonomy and role of stress on the organizational commitment of the employees; here job autonomy and role stress are independent variables

- **Dependent variable:** The most important variable to be studied and analysed in research study is the effect-dependent variable (DV). The entire research process is involved in either describing this variable or investigating the probable causes of the observed effect. Thus, this in essence has to be a measurable variable. For example, in the organic food study, the consumer's purchase intentions as well as sales of organic food products in the domestic market, could serve as the dependent variable.

- **Moderating variables:** Moderating variables are the ones that have a strong effect on the relationship between the independent and dependent variables. These variables have to be considered in the expected pattern of relationship as they modify the direction as well as the magnitude of the independent–dependent association. In the organic food study, the strength of the relation between attitude and intention might be modified by the education and the income level of the buyer. Here, education and income are the moderating variables (MVs).

There might be instances when confusion might arise between a moderating variable and an independent variable. Consider the following situation:

Proposition 1: Turnover intention (DV) is an inverse function of organizational commitment (IV), especially for workers who have a higher job satisfaction level (MV).

While another study might have the following proposition to test.

Proposition 2: Turnover intention (DV) is an inverse function of job satisfaction (IV), especially for workers who have a higher organizational commitment (MV).

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Thus, the two propositions are studying the relation between the same three variables. However the decision to classify one as independent and the other as moderating depends on the research interest of the decision maker.

Extraneous variables: Besides the moderating variables, there might still exist a number of extraneous variables (EVs) which could affect the defined relationship but might have been excluded from the study. These would most often account for the chance variations observed in the research investigation. They might not heavily impact the direction of the findings. However, in case the effect is substantial, the researcher might try to block their effect by using an experimental and a control group (This concept will be discussed later in Unit 3).

At this stage, we can clearly distinguish between the different kinds of variables discussed above. An independent variable is the most important cause which can explain the variance in the dependent variable. The moderating variable is a contributing variable which might affect the relationship between the independent and the dependent variable. The extraneous variables are outside the domain of the study and yet may also affect the dependent variable.

Check Your Progress

4. Name some of the academically accepted referencing styles in management.
5. State the advantage of the developing a theoretical framework.
6. What is another name for causal variable?
7. Which variable can affect the relationship between the independent and the dependent variable?

2.6 FORMULATING THE RESEARCH HYPOTHESES

The problem identification process ends in the hypotheses formulation stage. Any assumption that the researcher makes on the probable direction of the results that might be obtained on completion of the research process is termed as a hypothesis. Unlike the research problem that generally takes on a question form, the hypotheses are always in a sentence form. The statements thus made can then be empirically tested. Kerlinger (1986) defines a hypothesis as '…a conjectural statement of the relationship between two or more variables.' According to Grinnell (1993), 'A hypotheses is written in such a way that it can be proven or disproven by valid and reliable data—it is in order to obtain these data that we perform our study'.

While designing any hypotheses, there are a few criteria that the researcher must fulfill. These are:

- A hypothesis must be formulated in simple, clear, and declarative form. A broad hypothesis might not be empirically testable. Thus, it might be

advisable to make the hypothesis unidimensional, and to be testing only one relationship between only two variables at a time.

- o Consumer liking for the electronic advertisement for the new diet drink will have positive impact on brand awareness of the drink.
- o High organizational commitment will lead to lower turnover intention.

- A hypothesis must be measurable and quantifiable.
- A hypothesis is a conjectural statement based on the existing literature and theories about the topic and not based on the gut feel of the researcher.
- The validation of the hypothesis would necessarily involve testing the statistical significance of the hypothesized relation.

2.6.1 Types of Research Hypotheses

The formulated hypothesis could be of two types:

Descriptive hypothesis: This is simply a statement about the magnitude, trend or behaviour of a population under study. Based on past records, the researcher makes some presumptions about the variable under study. For example:

- Students from the pure science background score 90–95 per cent on a course on quantitative methods.
- The current advertisement for the diet drink will have a 20–25 per cent recall rate.
- The literacy rate in the city of Indore is 100 per cent.

Relational hypothesis: These are the typical kind of hypotheses which state the expected relationship between two variables. While stating the relation if the researcher makes use of words such as increase, decrease, less than or more than, the hypothesis is stated to be directional or one-tailed hypothesis.

For example,

- Higher the likeability of the advertisement, higher is the recall rate.
- Higher the work exhaustion experienced by the BPO professional, higher is the turnover intention of the person.

However, sometimes the researcher might not have reasonable supportive data to hypothesize the expected direction of the relationship. In this case he or she would leave the hypothesis as non-directional or two-tailed.

For example,

- There is a relation between quality of working life and job satisfaction experienced by employees.
- Ban on smoking has an impact on cigarette sales.
- Anxiety is related to performance.

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The hypotheses discussed in this section are in a verbal sentence form. In later sections, we will learn that it needs to be reduced to a statistical form for any data analysis to be done. The nature and formulation of the statistical hypotheses will be discussed in Unit 10.

2.7 WRITING A RESEARCH PROPOSAL

We have learnt that research always begins with a purpose. Either this is the researcher's own pursuit, or it is carried out to address and answer a specific managerial question and arrive at a solution. This clear statement of purpose guides the research process and must be converted into a plan for the study. This framework or plan is termed as the research proposal. A research proposal is a formal document that presents the research objectives, design of achieving these objectives and the expected outcomes/deliverables of the study.

This step is essential both for academic and corporate research, as it clearly establishes the research process to be followed to address the research questions. In a business or corporate setting, this step is often preceded by a PR (Proposal Request). Here the manager or the corporate spells out his decision problem and requests the potential suppliers of research to work out a research plan/proposal to address the stated issues.

Another advantage of a formal proposal is that sometimes the manager may not be able to clearly tell his problem or the researcher might not be able to understand and convert the decision into a workable research problem. The researcher lists the objectives of the study and then together with the manager, is able to review whether or not the listed objectives and direction of the study will be able to deliver output for arriving at a workable solution.

For the researcher, the document provides an opportunity to identify any shortfalls in the logic or the assumption of the study. It also helps to monitor the methodical work being carried out to accomplish the project.

2.7.1 Contents of a research proposal

There is a broad framework that most proposals follow. In this section we will briefly discuss these steps.

Executive summary

This is a broad overview that gives the purpose and objective of the study. In a short paragraph, the author gives a summary about the management problem/ academic concern.

Background of the problem

This is the detailed background of the management problem. It requires a sequential and systematic build-up to the research questions and also why the study should

be done. The researcher has to be able to demonstrate that there could be a number of ways in which the management dilemma could be answered. For example, a pharmaceutical company develops a new hair growing solution and packages it in two different types of bottles. They want to know which one people will buy. The product testing could be done internally in the company, or the two sample bottles could be formulated and tested for their acceptability amongst likely consumers or retailers keeping the product; or the two types would be developed and test launched and tested for their sales potential. The researcher thus has to spell out all probabilities and then systematically and logically argue for the research study. This section has to be objective and written in simple language, avoiding any metaphors or idioms to dramatize the plan. The logical arguments should speak for themselves and be able to convince the reader of the need for the study in order to find probable solutions to the management dilemma.

Problem statement and research objectives

The clear definition of the problem broken down into specific objectives is the next step. This section is crisp and to the point. It begins by stating the main thrust area of the study. For example, in the above case, the problem statement could be:

To test the acceptability of a spray or capped bottle dispenser for a new hair growing formulation.

The basic objectives of this research would be to:

- Determine the comparative preference of the two prototypes amongst customers of hair growing solutions.
- To conduct a sample usage test of both the bottles with the identified population.
- To assess the ease of use for the bottles amongst the respondents.
- To prepare a comparative analysis of the advantages and problems associated with each bottle, on the basis of the sample usage test.
- To prepare a detailed report on the basis of the findings.

If the study is addressed towards testing some assumptions in the form of hypotheses, they have to be clearly stated in this section.

Research design

This is the working section of the proposal as it needs to indicate the logical and systematic approach intended to be followed in order to achieve the listed objectives. This would include specifying the population to be studied, the sampling process and plan, sample size and selection. It also details the information areas of the study and the probable sources of data, i.e., the data collection methods. In case the process has to include an instrument design, then the intended approach needs to be detailed here. A note of caution has to be given here: this is not a

simple statement of the sampling and data collection plan; it requires a clear and logical justification of using the techniques over the methods available for research.

Scheduling the research

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The time-bound dissemination of the study with the major phases of the research has to be presented. This can be done using the CPM/GANTT/PERT charts. This gives a clear way for monitoring and managing the research task. It also has the additional benefit of providing the researcher with a means of spelling out the payment points linked to the delivered phase outputs.

Results and outcomes of the research

Here the clear terms of contract or expected outcomes of the study have to be spelt out. This is essential even if it is an academic research. The expected deliverables need to clearly demonstrate how the researcher intends to link the findings of the proposed study design to the stated research objectives. For example, in the pharmaceutical study, the expected deliverables are:

- To identify the usage problems with each bottle type.
- To recommend on the basis of the sample study on which bottle to use for packaging the liquid.

Costing and budgeting the research

In all instances of business research, both internal and external, an estimated cost of the study is required.

In addition to these sections, academic research proposals require a section on review of related literature; this generally follows the 'problem background' section. If the proposal is meant to establish the credentials of the research supplier, then detailed qualifications of the research team, including the research experience in the required or related area, help to aid in the selection of the research proposal.

Sometimes, the research study requires an understanding of some technical terms or explanations of the constructs under study; in such cases the researcher needs to attach a glossary of terms in the appendix of the research proposal.

The last section of the proposal is to state the complete details of the references used in the formulation of the research proposal. Thus the data source and address have to be attached with the formulated document.

2.7.2 Types of Research Proposals

Basically, the proposals formulated could be of three types:

- Academic research proposals
- Internal organizational proposal
- External organizational proposals

Academic research proposal

The academic research proposal might be generated by students or academicians pursuing the study for fundamental academic research. These kind of studies need extensive search of past studies and data on the topic of study. An example is an academician wanting to explore the viability of different eco-friendly packaging options available to a manufacturer.

Internal organizational proposal

The internal organizational proposals are conducted within an organization and are submitted to the management for approval and funding. They are of a highly focused nature and are oriented towards solving immediate problems. For example, a pharmaceutical company, which has developed a new hair growing formulation wants to test whether to package the liquid in a spray type or capped dispenser. The solutions are time-driven and applicability is only for this product. These studies do not require extensive literature review but do require clearly stated research objectives, for the management to assess the nature of work required.

External organizational proposals

External organizational proposals have the base or origin within the company, but the scope and nature of the study requires a more structured and objective research. For example, if the above stated pharmaceutical company wishes to explore the herbal cosmetic market and wants market analysis and feasibility study conducted; the PR might be spelt out to solicit proposals to address the research question, and execute an outsourced research.

Check Your Progress

8. Name the hypotheses that talks about relation between two or more variables.
9. What should the researcher do when he/she does not have a reasonable supportive data to hypothesize the expected direction of the relationship?
10. What is the research proposal preceded by in a corporate or business setting?
11. Mention the tools through which the time-bound dissemination of the study with the major phases of the research is presented.

2.8 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The management decision problem must be reduced to a research problem which can lead to a scientific enquiry.

2. Linear relationships are tested under simple research problems.
3. The types of problem faced by the decision maker at the start of the problem recognition process are that it might be related to actual and immediate difficulties faced by the manager or gaps experienced in the existing body of knowledge.
4. Some of the academically accepted referencing styles in management are the Publication Manual of the American Psychological Association (2001) and the Chicago Manual of Style (1993) are academically accepted as referencing styles in management.
5. The advantage of developing a theoretical framework is that it clearly shows the expected direction of the relationships between the concepts. There is also an indication of whether the relationship would be positive or negative.
6. Independent variable is another name for causal variable.
7. Moderating variable is the contributing variable which may affect the relationship between the independent and the dependent variable.
8. The hypotheses that talks about the relation between two or more variables is known as the relational hypotheses.
9. When the researcher does not have reasonable supportive data to hypothesize the expected direction of the relationship between variable that he/she should leave the hypotheses as non-directional or two-tailed.
10. In a business or corporate setting, the research proposal is preceded by a PR (Proposal Request). Here the manager or the corporate spells out his decision problem and requests the potential suppliers of research to work out a research plan/proposal to address the stated issues.
11. The time-bound dissemination of the study with the major phases of the research is presented using the CPM/GANTT/PERT charts.

2.9 SUMMARY

- The most important step in research is to identify the decision to be made and how it can be converted into a research problem
- The problem definition process is a well-integrated, linked and stepwise process.
- There are some essential elements of a typical research problem. These include the unit of analysis—which is the individual or group that is to be studied. The second element is a clear definition of the variables under study.
- At this stage, the researcher should be able to specify what is the causal or independent variable and which is the effect or dependent variable under study. Also, it is best to acknowledge the effect or presence of any external

variables which might have a contingent effect on the cause and effect relationship that is to be studied. These can be further classified as moderator, intervening, and extraneous variables.

- It is advisable to the researcher to construct a model or theoretical framework based on the process of problem formulation. This is a recommended but not necessarily an essential step as some studies might be of a nature that the intent is to conduct the study and then arrive at a theory or a model.
- The problem formulation process ultimately ends as a research hypothesis.
- The entire step wise in the shape of a formal plan to be followed is made. This is called the research proposal
- There are three different kinds of research proposals available to the researcher – academic, internal and external.

2.10 KEY WORDS

- **Dependent variable:** The outcome or effect that is being studied in the research
- **Extraneous variable**: Any variable that may have an effect on the dependent variable and is not part of the study.
- **Hypothesis**: Any pre-supposition made about the likely outcome of the study.
- **Independent variable**: The variables that might have an effect on the dependent variable
- **Unit of analysis**: The respondent population to be studied

2.11 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. How would you distinguish between a management decision problem and a management research problem?
2. What is a research hypothesis? Do all researches require hypotheses formulation?
3. What are the steps involved in writing a research proposal. Give examples.

Long-Answer Questions

1. Do all decision problems require research? Explain and illustrate with examples.

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2. Explain the step wise process of problem identification with an example
3. What are the components of a sound research problem? Illustrate with examples.
4. Explain the different types of hypotheses available for research with examples.
5. What are the different kinds of research proposals that can be formulated?

2.12 FURTHER READINGS

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UNIT 3 RESEARCH DESIGNS

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Structure

3.0 INTRODUCTION

In the last unit, we studied the defining of the research problem and the formulation of the research hypothesis. However, in research, it is not enough to define the problem formulate the hypotheses. It has been found by research scholars and managers alike that most research studies do not result in any significant findings because of a faulty research design. Most researchers feel that once the problem is defined and hypotheses are made, one can go ahead and collect the data on a specified group, or sample, and then analyse it using statistical tests. However, unless the the formulated research problem and the study hypotheses is tested through a well defined plan, answers are going to be based on hit and trial rather than any sound logic.

The design approach available to the researcher are many and will depend on whether the study is of descriptive or conclusive nature. The designs range from very simple, loosely structured to highly scientific experimentation. In this unit, we will study the complete choice of designs, along with detailed reasoning on which design should be used under what conditions. Just as experiments in science, in business research also there are chances of error and this needs to be understood and controlled for more accurate results for the decision maker.

3.1 OBJECTIVES

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After going through this unit, you will be able to:

- Describe the nature of research designs
- Explain exploratory research designs
- Discuss the designs used for descriptive studies
- Describe the range of experimental designs available
- Identify and control the errors in research designs

3.2 MEANING, NATURE AND CLASSIFICATION OF RESEARCH DESIGNS

Once you have established the 'what' of the study, i.e., the research problem, the next step is the 'how' of the study, which specifies the method of achieving the research objectives. In other words, this is the research design.

Green *et al*. (2008) defines research design as 'the specification of methods and procedures for acquiring the information needed. It is the overall operational pattern or framework of the project that stipulates what information is to be collected from which sources by what procedures. If it is a good design, it will ensure that the information obtained is relevant to the research questions and that it was collected by objective and economical procedures.'

Thyer (1993) states that, 'A traditional research design is a blueprint or detailed plan for how a research study is to be completed—operationalizing variables so they can be measured, selecting a sample of interest to study, collecting data to be used as a basis for testing hypotheses, and analysing the results.' Sellitz *et al.* (1962) state that, 'A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure.'

One of the most comprehensive and holistic definition has been given by Kerlinger (1995). He refers to a research design as, '….. a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problems. The plan is the complete scheme or programme of the research. It includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data.'

Thus, the formulated design must ensure three basic principles:

(a) Convert the research question and the stated assumptions/hypotheses into variables that can be measured.

(b) Specify the process to complete the above task.

(c) Specify the 'control mechanism(s)' to follow so that the effect of other variables that could have an effect on the outcome of the study have been controlled.

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At this stage, one needs to understand the difference between research design and research method. While the design is the specific framework that has been created to seek answers to the research question, the research method is the technique to collect the information required to answer the research problem, given the created framework.Thus, research designs have a critical and directive role to play in the research process. The execution details of the research question to be investigated are referred to as the research design.

The researcher has a number of designs available to him for investigating the research objectives. The classification that is universally followed is the one based upon the objective or the purpose of the study. A simple classification that is based upon the research needs ranging from simple and loosely structured to the specific and more formally structured. The best way is to view the designs on a continuum as shown in Figure 3.1. Hence, in case the research objective is diffused and requires a refinement, one uses the exploratory design, and this might lead to the slightly more concrete descriptive design—here one describes all the aspects of the construct and concepts under study. This leads to a more structured and controlled experimental research design.

Figure 3.1 illustrates research designs as a continuous process.

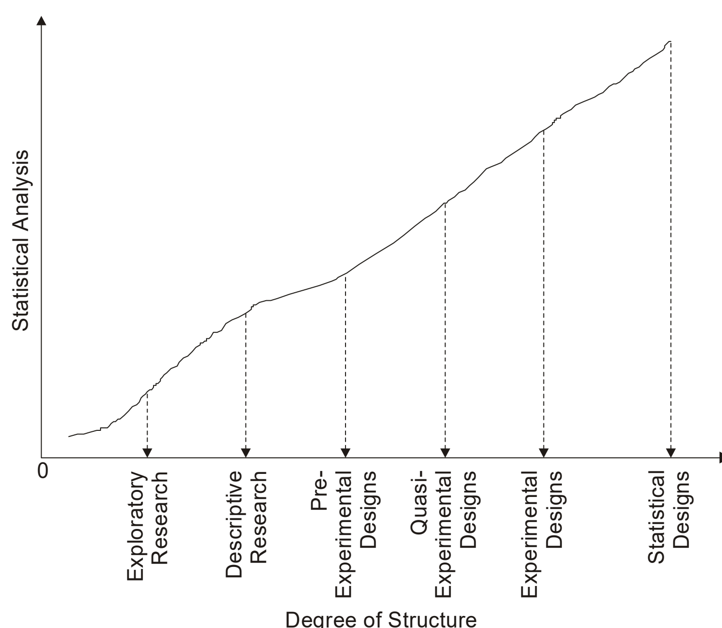


Fig. 3.1 *Research Designs—A Continuous Process*

In the following sections, you will study the broad classification of research design.

3.3 EXPLORATORY RESEARCH DESIGNS

Exploratory designs, as stated earlier, are the simplest and most loosely structured designs. As the name suggests, the basic objective of the study is to explore and obtain clarity about the problem situation. It is flexible in its approach and mostly

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involves a qualitative investigation. The sample size is not strictly representative and at times it might only involve unstructured interviews with a couple of subject experts. The essential purpose of the study is to:

- Define and understand the research problem to be investigated.
- Explore and evaluate the diverse and multiple research opportunities.
- Assist in the development and formulation of the research hypotheses.
- Define the variables and constructs under study.
- Identify the possible nature of relationships that might exist between the variables under study.
- Explore the external factors and variables that might impact the research.

For example, a university professor might decide to do an exploratory analysis of the new channels of distribution that are being used by the marketers to promote and sell products and services. To do this, a structured and defined methodology might not be essential as the basic objective is to understand how to teach this to students of marketing. The researcher can make use of different methods and techniques in an exploratory research- like secondary data sources, unstructured or structured observations, expert interviews and focus group discussions with the concerned respondent group. Here, we will discuss them in brief in the light of their use in exploratory research.

3.3.1 Secondary Resource Analysis

Secondary sources of data, as the name suggests, are data in terms of the details of previously collected findings in facts and figures—which have been authenticated and published. It is a fast and inexpensive way of collecting information. The past details can sometimes point out to the researcher that his proposed research is redundant and has already been established earlier. Secondly, the researcher might find that a small but significant aspect of the concept has not been addressed and should be studied. For example, a marketer might have extensively studied the potential of the different channels of communication for promoting a 'home maintenance service' in Greater Mumbai. However, there is no impact of any mix that he has tested. An anthropologist research associate, on going through the findings, postulated the need for studying the potential of WOM (word of mouth) in a close-knit and predominantly Parsi colony where this might be the most effective culture-dependent technique that would work. Thus, such insights might provide leads for carrying out an experimental and conclusive research subsequently.

Another valuable secondary resource is the compiled and readily available databases of the entire industry, business or construct. These might be available on free and public domains or through a structured acquisition process and cost. These are both government and non-government publications. Based on the resources and the level of accuracy required, the researcher might decide to make use of them.

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3.2.2 Case Study Method

Another way of conducting an exploratory research is the case study method. This requires an in-depth study and is focused on a single unit of analysis. This unit could be an employee or a customer; an organization or a complete country analysis. They are by their nature, generally, post-hoc studies and report those incidences which might have occurred earlier. The scenario is reproduced based upon the secondary information and a primary interview/discussion with those involved in the occurrence. Thus, there might be an element of bias as the data, in most cases, becomes a judgemental analysis rather than a simple recounting of events.

For example, BCA Corporation wants to implement a performance appraisal system in the organization and is debating between the merits of a traditional appraisal system and a 360° appraisal system. For a historical understanding of the two techniques, the HR director makes use of books on the subject. However, for better understanding, he should do an in-depth case accounting of Allied Association which had implemented traditional appraisal formats, and Surakhsha International which uses 360° appraisal systems. Thus, the two exploratory researches carried out were sufficient to arrive at a decision in terms of what would be best for the organization.

3.3.3 Expert Opinion Survey

At times, there might be a situation when the topic of a research is such that there is no previous information available on it. In these cases, it is advisable to seek help from experts who might be able to provide some valuable insights based upon their experience in the field or with the concept. This approach of collecting particulars from significant and knowledgeable people is referred to as the expert opinion survey. This methodology might be formal and structured and is useful when authenticated or supported by a secondary/primary research or it might be fluid and unstructured and might require an in-depth interviewing of the expert. For example, the evaluation of the merit of marketing organic food products in the domestic Indian market cannot be done with the help of secondary data as no such structured data sources exist. In this case the following can be contacted:

- Doctors and dieticians as experts would be able to provide information whether consumers would eat organic food products as a healthier alternative.
- Chefs who are experimental and would like to look at providing better value to their clients.
- Retailers who like to sell contemporary new products.

These could be useful in measuring the viability of the proposed plan. Discussions with knowledgeable people may reveal some information regarding who might be considered as potential consumers. Secondly, the question whether a healthy proposition or a lifestyle proposition would work better to capture the

targeted consumers needs to be examined.Thus, this method can play a directional role in shaping the research study.

3.3.4 Focus Group Discussions

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Another way to conduct a exploratory analysis is carry out discussions with individuals associated with the problem under study. This technique, though originally from sociology, is actively used in business research. In a typical focus group, there is a carefully selected small set of individuals representative of the larger respondent population under study. It is called a focus group as the selected members discuss the concerned topic for the duration of 90 minutes to, sometimes, two hours. Usually the group is made up of six to ten individuals. The number thus stated is because less than six would not be able to throw enough perspectives for the discussion and there might emerge a one-sided discussion on the topic. On the other hand, more than ten might lead to more confusion rather than any fruitful discussion and that would be unwieldy to manage. Generally, these discussions are carried out in neutral settings by a trained observer, also referred to as the moderator. The moderator, in most cases, does not participate in the discussion. His prime objective is to manage a relatively non-structured and informal discussion. He initiates the process and then maneuvers it to steer it only to the desired information needs. Sometimes, there is more than one observer to record the verbal and non-verbal content of the discussion. The conduction and recording of the dialogue requires considerable skill and behavioural understanding and the management of group dynamics. In the organic food product study, the focus group discussions were carried out with the typical consumers/buyers of grocery products. The objective was to establish the level of awareness about health hazards, environmental concerns and awareness of organic food products. A series of such focus group discussions carried out across four metros—Delhi, Mumbai, Bengaluru and Hyderabad—revealed that even though the new age consumer was concerned about health, the awareness about organic products varied from extremely low to non-existent. (*This study was carried out in the year 2004–05 by one of the authors for an NGO located in Delhi).*

Check Your Progress

1. State the difference between the research design and research method.
2. Which unit of analysis is the focus of the case study method?
3. Define expert opinion survey.

3.4 DESCRIPTIVE RESEARCH DESIGNS

As the name implies, the objective of descriptive research studies is to provide a comprehensive and detailed explanation of the phenomena under study. The

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intended objective might be to give a detailed sketch or profile of the respondent population being studied. For example, to design an advertising and sales promotion campaign for high-end watches, a marketer would require a holistic profile of the population that buys such luxury products. Thus a descriptive study, (which generates data on *who, what, when, where, why* and *how* of luxury accessory brand purchase) would be the design necessary to fulfill the research objectives.

Descriptive research thus are conclusive studies. However, they lack the precision and accuracy of experimental designs, yet it lends itself to a wide range of situations and is more frequently used in business research. Based on the time period of the collection of the research information, descriptive research is further subdivided into two categories: cross-sectional studies and longitudinal studies.

3.4.1 Cross-sectional Studies

As the name suggests, cross-sectional studies involve a slice of the population. Just as in scientific experiments one takes a cross-section of the leaf or the cheek cells to study the cell structure under the microscope, similarly one takes a current subdivision of the population and studies the nature of the relevant variables being investigated.

There are two essential characteristics of cross-sectional studies:

- The cross-sectional study is carried out at a single moment in time and thus the applicability is most relevant for a specific period. For example, one cross-sectional study was conducted in 2002 to study the attitude of Americans towards Asian-Americans, after the 9/11 terrorist attack. This revealed the mistrust towards Asians. Another cross-sectional study conducted in 2012 to study the attitude of Americans towards Asian-Americans revealed more acceptance and less mistrust. Thus the cross-sectional studies cannot be used interchangeably. .
- Secondly, these studies are carried out on a section of respondents from the population units under study (e.g., organizational employees, voters, consumers, industry sectors). This sample is under consideration and under investigation only for the time coordinate of the study.

There are also situations in which the population being studied is not of a homogeneous nature but composed of different groups. Thus it becomes essential to study the sub-segments independently. This variation of the design is termed as *multiple cross-sectional studies*. Usually this multi-sample analysis is carried out at the same moment in time. However, there might be instances when the data is obtained from different samples at different time intervals and then they are compared. *Cohort analysis* is the name given to such cross-sectional surveys conducted on different sample groups at different time intervals. Cohorts are essentially groups of people who share a time zone or have experienced an event that took place at a particular time period. For example, in the post-9/11 cross-sectional study done in 2002, we study and compare the attitudes of middle-aged

Americans versus teenaged Americans towards Asian-Americans. These two American groups are separate cohorts and this would be a cohort analysis. Thus the teenage American is one cohort and the middle-aged cohort is separate and thinks differently.

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The technique is especially useful in predicting election results, cohorts of males–females, different religious sects, urban–rural or region-wise cohorts are studied by leading opinion poll experts like Nielsen, Gallup and others. Thus, Cross-sectionals studies are extremely useful to study current patterns of behaviour or opinion.

3.4.2 Longitudinal Studies

A single sample of the identified population that is studied over a longer period of time is termed as a longitudinal study design. A panel of consumers specifically chosen to study their grocery purchase pattern is an example of a longitudinal design. There are certain distinguishing features of the same:

- The study involves the selection of a representative panel, or a group of individuals that typically represent the population under study.
- The second feature involves the repeated measurement of the group over fixed intervals of time. This measurement is specifically made for the variables under study.
- A distinguishing and mandatory feature of the design is that once the sample is selected, it needs to stay constant over the period of the study. That means the number of panel members has to be the same. Thus, in case a panel member due to some reason leaves the panel, it is critical to replace him/her with a representative member from the population under study.

Longitudinal study using the same section of respondents thus provides more accurate data than one using a series of different samples. These kinds of panels are defined as true panels and the ones using a different group every time are called omnibus panels. The advantages of a true panel are that it has a more committed sample group that is likely to tolerate extended or long data collecting sessions. Secondly, the profile information is a one-time task and need not be collected every time. Thus, a useful respondent time can be spent on collecting some research-specific information.

However, the problem is getting a committed group of people for the entire study period. Secondly, there is an element of mortality and attrition where the members of the panel might leave midway and the replaced new recruits might be vastly different and could skew the results in an absolutely different direction. A third disadvantage is the highly structured study situation which might be responsible for a consistent and structured behaviour, which might not be the case in the real or field conditions.

Check Your Progress

4. Define cohort analysis.
5. What are omnibus panels?

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3.5 EXPERIMENTAL DESIGNS

Experimental designs are conducted to infer causality. In an experiment, a researcher actively manipulates one or more causal variables and measures their effects on the dependent variables of interest. Since any changes in the dependent variable may be caused by a number of other variables, the relationship between cause and effect often tends to be probabilistic in nature. It is virtually impossible to prove a causality. One can only infer a cause-and-effect relationship.

The necessary conditions for making causal inferences are: (i) concomitant variation, (ii) time order of occurrence of variables and (iii) absence of other possible causal factors. The first condition implies that cause and effect variables should have a high correlation. The second condition means that causal variable must occur prior to or simultaneously with the effect variable. The third condition means that all other variable except the one whose influence we are trying to study should be absent or kept constant.

There are two conditions that should be satisfied while conducting an experiment. These are:

(i) **Internal validity:** Internal validity tries to examine whether the observed effect on a dependent variable is actually caused by the treatments (independent variables) in question. For an experiment to be possessing internal validity, all the other causal factors except the one whose influence is being examined should be absent. Control of extraneous variables is a necessary condition for inferring causality. Without internal validity, the experiment gets confounded.

(ii) **External validity:** External validity refers to the generalization of the results of an experiment. The concern is whether the result of an experiment can be generalized beyond the experimental situations. If it is possible to generalize the results, then to what population, settings, times, independent variables and the dependent variables can the results be projected. It is desired to have an experiment that is valid both internally and externally. However, in reality, a researcher might have to make a trade-off between one type of validity for another. To remove the influence of an extraneous variable, a researcher may set up an experiment with artificial setting, thereby increasing its internal validity. However, in the process the external validity will be reduced.

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There are four types of experimental designs. These are explained below:

1. **Pre-experimental designs:** There are three designs under this – one short case study where observation is taken after the application of treatment, one group pre test-post test design where one observation is taken prior to the application of treatment and the other one after the application of treatment, and static group comparison, where there are two groups – experimental group and control group. The experiment group is subjected to treatment and a post test measurement is taken. In the control group measurement is taken at the time when it was done for experimental group. These do not make use of any randomization procedures to control the extraneous variables. Therefore, the internal validity of such designs is questionable.
2. **Quasi-experimental designs**: In these designs the researcher can control when measurements are taken and on whom they are taken. However, this design lacks complete control of scheduling of treatment and also lacks the ability to randomize test units' exposure to treatments. As the experimental control is lacking, the possibility of getting confounded results is very high. Therefore, the researchers should be aware of what variables are not controlled and the effects of such variables should be incorporated into the findings.
3. **True experimental designs:** In these designs, researchers can randomly assign test units and treatments to an experimental group. Here, the researcher is able to eliminate the effect of extraneous variables from both the experimental and control group. Randomization procedure allows the researcher the use of statistical techniques for analysing the experimental results.
4. **Statistical designs:** These designs allow for statistical control and analysis of external variables. The main advantages of statistical design are the following:
    - The effect of more than one level of independent variable on the dependent variable can be manipulated.
    - The effect of more than one independent variable can be examined.
    - The effect of specific extraneous variable can be controlled.

    Statistial design includes the following designs:

    (i) *Completely randomized design:* This design is used when a researcher is investigating the effect of one independent variable on the dependent variable. The independent variable is required to be measured in nominal scale i.e. it should have a number of categories. Each of the categories of the independent variable is considered as the treatment. The basic assumption of this design is that there are no differences in the test units. All the test units are treated alike and randomly assigned to the test groups. This means that there are no extraneous variables that could influence the outcome.

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Suppose we know that the sales of a product is influenced by the price level. In this case, sales are a dependent variable and the price is the independent variable. Let there be three levels of price, namely, low, medium and high. We wish to determine the most effective price level i.e. at which price level the sale is highest. Here, the test units are the stores which are randomly assigned to the three treatment level. The average sales for each price level is computed and examined to see whether there is any significant difference in the sale at various price levels. The statistical technique to test for such a difference is called analysis of variance (ANOVA).

The main limitation of completely randomized designs is that it does not take into account the effect of extraneous variables on the dependent variable. The possible extraneous variables in the present example could be the size of the store, the competitor's price and price of the substitute product in question. This design assumes that all the extraneous factors have the same influence on all the test units which may not be true in reality. This design is very simple and inexpensive to conduct.

(ii) *Randomized block design:* As discussed, the main limitation of the completely randomized design is that all extraneous variables were assumed to be constant over all the treatment groups. This may not be true. There may be extraneous variables influencing the dependent variable. In the randomized block design it is possible to separate the influence of one extraneous variable on a particular dependent variable, thereby providing a clear picture of the impact of treatment on test units.

In the example considered in the completely randomized design, the price level (low, medium and high) was considered as an independent variable and all the test units (stores) were assumed to be more or less equal. However, all stores may not be of the same size and, therefore, can be classified as small, medium and large size stores. In this design, the extraneous variable, like the size of the store could be treated as different blocks. Now the treatments are randomly assigned to the blocks in such a way so that each treatment appears in each block at least once. The purpose of forming these blocks is that it is hoped that the scores of the test units within each block would be more or less homogeneous when the treatment is absent. What is assumed here is that block (size of the store) is correlated with the dependent variable (sales). It may be noted that blocking is done prior to the application of the treatment.

In this experiment one might randomly assign 12 small-sized stores to three price levels in such a way that there are four stores for each of the three price levels. Similarly, 12 medium-sized stores and

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12 large-sized stores may be randomly assigned to three price levels. Now the technique of analysis of variance could be employed to analyse the effect of treatment on the dependent variable and to separate out the influence of extraneous variable (size of store) from the experiment.

(iii) *Factorial design:* A factorial design may be employed to measure the effect of two or more independent variables at various levels. The factorial designs allow for interaction between the variables. An interaction is said to take place when the simultaneous effect of two or more variables is different from the sum of their individual effects. An individual may have a high preference for mangoes and may also like ice-cream, which does not mean that he would like mango ice cream, leading to an interaction.

The sales of a product may be influenced by two factors, namely, price level and store size. There may be three levels of price—low (A_1), medium (A_2) and high (A_3). The store size could be categorized into small (B_1) and big (B_2). This could be conceptualized as a two-factor design with information reported in the form of a table. In the table, each level of one factor may be presented as a row and each level of another variable would be presented as a column. This example could be summarized in the form of a table having three rows and two columns. This would require 3 × 2 = 6 cells. Therefore, six different levels of treatment combinations would be produced each with a specific level of price and store size. The respondents would be randomly selected and randomly assigned to the six cells.

The tabular presentation of 3 × 2 factorial design is given in Table 3.1.

Table 3.1 *3 × 2 Factorial Design for Price Level and Store Size*

Price	Store	
	Small (B_1)	**Big (B_2)**
Low Level (A_1)	A_1B_1	A_1B_2
Medium Level (A_2)	A_2B_1	A_2B_2
High Level (A_3)	A_3B_1	A_3B_2

Respondents in each cell receive a specified treatment combination. For example, respondents in the upper left hand corner cell would face small level of price and small store. Similarly, the respondents in the lower right hand corner cell will be subjected to both high price level and big store.

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The main advantages of factorial design are:

- It is possible to measure the main effects and interaction effect of two or more independent variables at various levels.
- It allows a saving of time and effort because all observations are employed to study the effects of each factor.
- The conclusion reached using factorial design has broader applications as each factor is studied with different combinations of other factors.

The limitation of this design is that the number of combinations (number of cells) increases with increased number of factors and levels. However, a fractional factorial design could be used if interest is in studying only a few of the interactions or main effects.

3.6 ERRORS AFFECTING RESEARCH DESIGN

We have discussed three types of research designs, namely, exploratory, descriptive and experimental. All of these have some scope of error. There could be various sources of errors in research design.

Exploratory research is conducted using focus group discussion, secondary data, analysis of case study and expert opinion survey. It is quite likely that members of the focus group have not been selected properly. Secondary data may not be free from errors (in fact, one needs to evaluate the methodology used in collecting such a data). Also, the experts chosen for the survey may not be experts in the field. As a matter of fact, getting an expert is very difficult task. All these factors could lead to errors in the exploratory design.

In the descriptive design, the purpose is to describe a phenomenon. For this one could use a structured questionnaire. It could always a happen that the respondents do not give correct responses to some of the questions, thereby resulting in wrong information.

In the true experimental design and statistical design, the respondents are selected at random which may not be the case in real life. Many a times, in actual business situation, the value judgements play very important role in selecting the respondents. Further, there can always be errors in observations.

Check Your Progress

6. Is it possible to prove a causality?
7. Name the type of experimental design in which researchers can randomly assign test units and treatments to an experimental group.
8. State the limitation of the factorial design.

3.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

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1. The difference between research design and research methods is that while the design is the specific framework that has been created to seek answers to the research question, the research method is the technique to collect the information required to answer the research problem, give the created framework.
2. The case study method is focused on the single unit of analysis.
3. An expert opinion survey is the approach of collecting particulars from significant and knowledgeable people.
4. Cohort analysis is the name given to such cross-sectional surveys conducted on different sample groups at different time intervals.
5. Omnibus panels are the type of longitudinal study using a different group every time.
6. It is virtually impossible to prove a causality. One can only infer a cause-and-effect relationship.
7. The type of experimental design in which researchers can randomly assign test units and treatments to an experimental group are true experimental designs.
8. The limitation of the factorial design is that the number of combinations increases with increased number of factors and levels.

3.8 SUMMARY

- Research design is the blueprint or the framework for carrying out the research study.
- The researcher has a number of designs available to him for investigating the research objectives. Based upon the objective or the purpose of the study, research design may be exporatory, descriptive or experimental.
- Exploratory designs are loosely structured and investigative in nature.
- In case the hypothesis formulated is descriptive in nature, the study design would also be descriptive. The study involves collecting the *who, what, why, where, why, when* and *how* about the population under study.
- Descriptive studies can further be divided into cross-sectional, i.e., studying a section of the population at a single time period. In case the study is

conducted on a single population, it is called as single cross-sectional and in case, it is done on more than one segment it is called multiple cross-sectional designs.

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- Another type of descriptive desgn is the longitudinal design. Here, a selected sample is studied at different intervals (fixed) of time to measure the variable(s) under study.
- Experimental designs are conducted to infer causality. There are four types of experimental designs – pre-experimental designs, quasi-experimental designs, true experimental designs and statistical designs

3.9 KEY WORDS

- **Case study method**: An in-depth study of a single unit of analysis. This could be an employee, the owner, a customer, a company or even a country.
- **Cross-sectional designs**: A descriptive study done on a representative group of people at a single moment in time.
- **Descriptive designs**: Research designs that describe in detail the phenomena under study.
- **Exploratory research design**: Loosely structured research design to explore and gain clarity about the research questions.
- **Focus group discussion**: A sociological method in which 6-10 people discuss the topic being researched.
- **Judgemental analysis:** Formation of a judgement based upon personal impressions rather than facts.
- **Longitudinal designs**: A single sample studied over a longer period of time. There are periodic measurements done of the study variable.
- **Test unit:** A unit on which treatment is applied.

3.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. How would you define research designs? What are the three principles to be taken care of when selecting a research design?
2. Distinguish between internal and external validity of the experiments.
3. What are the various sources of errors?

Long-Answer Questions

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1. What are exploratory designs? What are the methods that can be used in an exploratory design?
2. What are descriptive designs? What are the different kinds of descriptive designs available?
3. Explain the four types of experimental designs.

3.11 FURTHER READINGS

Chawla D and Sondhi N. 2016. *Research Methodology: Concepts and Cases*, 2nd edition. New Delhi: Vikas Publishing House.

Easterby-Smith, M, Thorpe, R and Lowe, A. 2002. *Management Research: An Introduction,* 2nd edn. London: Sage.

Grinnell, Richard Jr (ed.). 1993. *Social Work, Research and Evaluation* 4th edn. Itasca, Illinois: F E Peacock Publishers.

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BLOCK - II
CLASSIFICATION OF DATA

NOTES

UNIT 4 PRIMARY AND SECONDARY DATA

Structure

4.0 INTRODUCTION

In the last unit, we discussed research design and its various aspects. Once the research design is in place, it is time to answer the research problem and hypotheses. But this cannot be done unless one collects the relevant information necessary for arriving at any suitable conclusions. The information thus collected is usually termed as data. The researcher has a choice of a wide variety of methods to collect the same. It has to be remembered that there might be a lot of information available on the topic under study; however you need to pick up only that information which is of direct relevance to the current problem under study.

The researcher can make use of data that has been collected and compiled earlier or alternately make use of methods that are problem specific. The decision to choose one over the other or to use a combination of methods depends on a number of deciding criteria. This unit will begin by making the reader aware of the methods of data collection available for research. Next, we will discuss the secondary data methods and then go on to discuss three most widely used primary data methods: observation, focus group discussion and interviews. The most popular and widely used method of primary data is the questionnaire method. This will be dealt with at length in Unit 6.

4.1 OBJECTIVES

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After going through this unit, you will be able to:

- Distinguish between different types of primary and secondary sources of data.
- Explain the relevance of secondary data in research.
- Identify the different types and sources of secondary data.
- Describe the method and uses of observation method.
- Discuss the method of focus group discussion.
- Identify and use the interview method for data collection.

4.2 CLASSIFICATION OF DATA

To understand the number of choices available to a researcher for collecting the study-specific information, one needs to be fully aware of the resources available for the study and the level of accuracy required. To appreciate the truth of this statement, one needs to examine the variety of methods available to the researcher. The data sources could be either problem specific and primary or historical and secondary in nature (Figure 4.1).

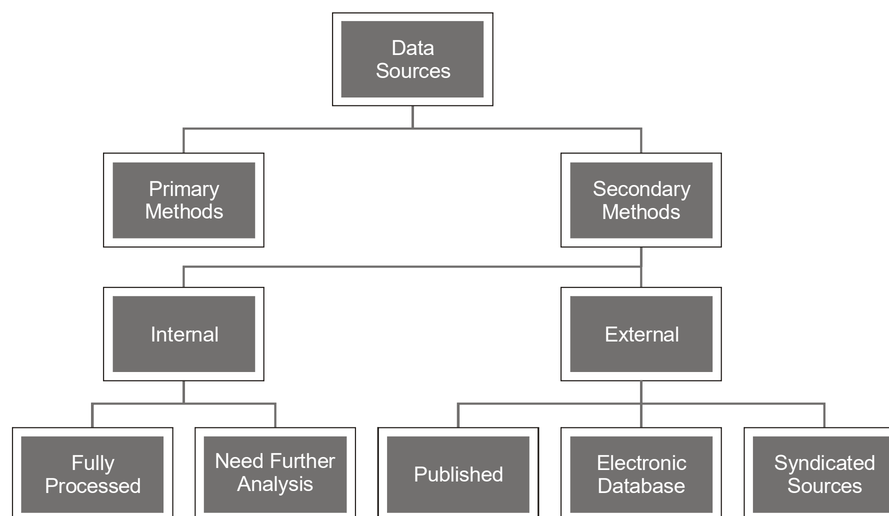


Fig. 4.1 *Sources of Research Information*

Primary data, as the name suggests, is original, problem- or project-specific and collected for the specific objectives and needs spelt out by the researcher. The accuracy and relevance is reasonably high. The time and money required for this are quite high and sometimes a researcher might not have the resources or the time or both to go ahead with this method. In this case, the researcher can look at alternative sources of data which are economical and reliable enough to take the

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study forward. These include the second category of data sources—namely the secondary data.

Secondary data as the name implies is that information which is not topical or research-specific and has been collected and compiled by some other researcher or investigative body. This type of data is recorded and published in a structured format, and thus, is quicker to access and manage. Secondly, in most instances, unless it is a data product, it is not too expensive to collect. The information required is readily available as a data product or as the audit information which the researcher or the organization can get and use it for arriving at quick decisions. In comparison to the original research-centric data, secondary data can be economically and quickly collected by the decision maker in a short span of time. However, one must remember that this is a little low on accuracy as what is primary and original for one researcher would essentially become secondary and historical for someone else.

Table 4.1 gives a snapshot of the major differences between the two methods.

Table 4.1 *Primary vs Secondary Data*

	Primary Data	**Secondary Data**
Collection purpose	For the problem at hand	For other problems
Collection process	Very involved	Rapid & easy
Collection cost	High	Relatively low
Collection time	Long	Short
Accuracy	As Desired	Not Known
Control	Complete	No Control
Period	Up to date	Dated

4.3 SECONDARY DATA

We have already discussed what secondary data is. Let us see what are its uses, types and sources.

4.3.1 Uses of Secondary Data

Secondary data can be used for multiple purposes as follows:

- **Problem identification and formulation stage:** Existing information on the topic under study is useful to help develop the research question.
- **Hypotheses designing:** Previous research studies done in the area could help in hypothesizing about expected results.
- **Sampling considerations:** There might be respondent related databases available to seek respondent statistics and relevant contact details. These would help during sampling for the study.

- **Primary base:** The secondary information collected can be used to design the primary data collection instruments, in order to phrase and design the right questions.
- **Validation board:** Earlier records and studies can also be used to support or validate the information collected through primary sources.

Before we examine the wide range of the secondary sources available to the business researcher, it is essential that one is aware of the advantages and disadvantages of using secondary sources.

4.3.2 Advantages and Disadvantages of Secondary Data

There are multiple advantages of using secondary data.

- **Resource advantage:** Any research that is making use of secondary information will be able to save immensely in terms of both cost and time
- **Accessibility of data:** The other major advantage of secondary sources is that it is very easy to access this data.
- **Accuracy and stability of data:** Data from recognized sources has the additional advantage of accuracy and reliability
- **Assessment of data:** It can be used to compare and support the primary research findings of the present study.

However, there is need for caution as well because in using secondary data, there might be some disadvantages like:

- **Applicability of data:** The information might not be directly suitable for our study. Also since it is past data it might not be applicable today.
- **Accuracy of data:** All data that is available might not be reliable and accurate.

4.3.3 Types and Sources of Secondary Data

As we saw earlier in Figure 4.1, secondary data can be divided into internal and external sources. Internal, as the name implies, is organization-or environment-specific source and includes the historical output and records available with the organization which might be the backdrop of the study. The data that is independent of the organization and covers the larger industry-scape would be available in the form of published material, computerized databases or data compiled by syndicated services. Discussed below are three major sources of data – internal, external, computer-stored data and syndicated databases.

1. Internal sources of data

Compilation of various kinds of information and data is mandatory for any organization that exists. Some sources of internal information are presented in Figure 4.2.

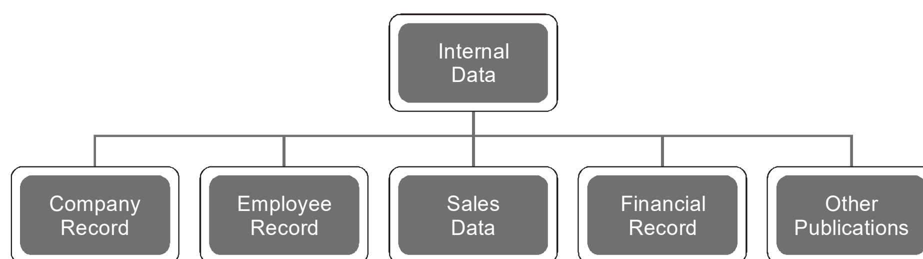


***Fig. 4.2** Internal Sources of Data*

- **Company records:** This includes all the data about the inception, the owners, and the mission and vision statements, infrastructure and other details, including both the process and manufacturing (if any) and sales, as well as a historical timeline of the events.
- **Employee records:** All details regarding the employees (regular and part-time) would be part of employee records.
- **Sales data:** This data can take on different forms:
  - (i) **Cash register receipt**
  - (ii) **Salespersons' call records:** This is a document to be prepared and updated every day by each individual salesperson.
  - (iii) **Sales invoices:** Customer who has placed an order with the company, his complete details including the size of the order, location, price by unit, terms of sale and shipment details (if any).
- **Financial records and sales reports**

  Besides this, there are other published sources like warranty records, CRM data and customer grievance data which are extremely critical in evaluating the health of a product or an organization.

2. External data sources

As stated earlier, information that is collected and compiled by an outside source that is external to the organization is referred to as *external* source of data. External sources of data include the following:

Published data: There could be two kinds of published data—one that is from the official and government sources and the other kind of data is that which has been prepared by individuals or private agencies or organizations.

Government sources: The Indian government publishes a lot of documents that are readily available and are extremely useful for the purpose of providing background data. A brief snapshot of some government data is given in Table 4.2.

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Table 4.2 Secondary Data—Government Publications

	Sub-type	Sources	Data	Uses
1.	Census data conducted every ten years throughout the country	Registrar General of India conducting census survey http://censusindia.gov.in/	Size of the population and its distribution by age, sex, occupation and income levels. 2010 census is taking many more variables to get a better picture of the population	Population information is significant as the forecasts of purchase, estimates of growth and development, as well as policy decisions can be made on this base
2.	Statistical Abstract India – annually	CSO (Central Statistical Organization) for the past 5 years http://www.mospi.gov.in/ cso_test1.htm	Education, health, residential information at the state level is part of this document	Making demand, estimations and a state level assessment of government support and policy changes can be made
3.	White paper on national income	CSO http://www.mospi.gov.in/ cso_test1.htm	Estimates of national income, savings and consumption	Significant indication of the financial trends; investment forecasts and monetary policy formulation
4.	Annual Survey of Industries – all industries	CSO No. of units, persons employed, capital output ratio, turnover, etc. http://www.mospi.gov.in/cso_test1.htm		Information on existing units gives perspective on the Industrial development and helps in creating the employee profile
5.	Monthly survey of selected industries	CSO http://www.mospi.gov.in/cso_test1.htm	Production statistics in detail	Demand–supply estimations
6.	Foreign Trade of	Director General of Commercial Intelligence	Exports and Imports	Forecast, manufacturing

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7.	Wholesale price index—weekly all India Consumer Price Index	Ministry of Commerce and Industry http://india.gov.in/sectors/commerce/ministry_commerce.php	Reporting of prices of products like food articles, foodgrains, minerals, fuel, power, lights, lubricants, textiles, chemicals, metal, machinery and transport	Establishing price bands of product categories; pricing estimations for new products; determining consumer spend
8.	Economic Survey – annual publication	Dept. of Economic Affairs, Ministry of Finance, patterns, currency and finance http://finmin.nic.in/the_ministry/dept_eco_affairs/	Descriptive reporting of the current economic status	Estimations of the future and evaluation of policy decisions and extraneous factors in that period
9.	National Sample Survey (NSS)	Ministry of Planning http://www.planningcommission.gov.in/	Social, economic, demographic, industrial and agricultural statistics.	Significant for making policy decisions as well as studying sociological patterns

Other data sources: This source is the most voluminous and most frequently used, in every research study. The information could be

- *Books and periodicals*
- *Guides:* including Industry guides
- *Directories and indices*
- *Standard non-governmental statistical data:* Some non-government data sources are presented in Table 4.3.

Table 4.3 Secondary Data—Non-government Publications

	Sub-type	Sources	Data	Uses
1.	Company Working Results – Stock Exchange Directory	Bombay Stock Exchange http://www.bseindia.com/	A complete database of the companies registered with the stock exchange and comprehensive details about stock policies and current share prices	Significant in determining the financial health of various sectors as well as assessment of corporate funding and predictions of outcomes

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2.	Status reports by various commodity boards	The commodity board or the industry associations like Jute Board, Cotton Industry, Sugar Association, Pulses Board, Metal Board, Chemicals, Spices, Fertilizers, Coir, Pesticides, Rubber, Handicrafts, Plantation Boards, etc.	Detailed information on current assets-in terms of units, current production figures and market condition	These are useful for individual sectors in working out their plans as well as evaluating causes of success or failure
3.	Industry Associatio ns on problems faced by private sector, etc.	FICCI, ASSOCHAM, AIMA, Association of Chartered Accountants and Financial Analysts, Indo-American Chamber of Commerce, etc. http://www.ficci.com/ http://www.assocham.org/ http://www.aima-ind.org/ www.iaccindia.com/	Cases/ comprehensive reports by the supplier or user or any other section associated with the sector	Cognizance of the gaps and problems in the effective functioning of the organization; trouble shooting
4.	Export related data – commodity wise	Leather Exports Promotion Council, Apparel Export Promotion Council, Handicrafts, Spices Tea, etc., Exim Bank etc. http://www.leatherindia.org/ http://www.aepcindia.com/	Product and country wise data on the export figures as well as information on existing policies related to the sector	To estimate the demand; gauge opportunities for trade and impetus required in terms of manufacturing and policy changes
5.	Retail Store Audit on pharmace-utical, veterinary, consumer products	ORG (Operations Research Group); Monthly reports on urban sector. Quarterly reports on rural sector	The touch point for this data is retailer, who provides the figures related to product sales; the data is very comprehensive and covers most brands. The data is region specific and covers both inventory and goods sold	Market analysis and market structure mapping with estimations of market share of leading brands. The audit can also be used to study consumption trends at different time periods or subsequent to sales promotion or other activities

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6.	National Reader-ship Surveys (NRS)	IMRB-survey of reading behaviour for different segments as well as different products http://www.imrbint.com/	Today these surveys are done by various bodies with different sample bases. Today the survey base has become younger, with the age of the reader lowered to 12+	Media planning and measuring exposure as well as reach for product categories
7.	THOMPSON INDICES: Urban market index, Rural market index	Hindustan Thompson Associates	All towns with population of more than one lakh are covered and information of demographic and socio-economic variables are given for each city with Mumbai as base. The rural index similarly covers about 400 districts with socio-economic indicators like value of agriculture output, etc.	The inclinations to purchase consumer products are directly related to socio-economic development of communities in general. The indices provide barometers to measure such potentials for each city and has implications for the researcher in terms of data collection sources

3. Computer-stored data

Information today is also available in an electronic form. The databases available to the researcher can be classified on the basis of the type of information or by the method of storage and recovery as described below. Figure 4.3 gives a classification of the sources of computerized data.

- ***Reference databases:*** These refer users to the articles, research papers, abstracts and other printed news contained in other sources. They provide online indices and abstracts and are thus also called bibliographic databases.
- ***Source databases:*** These provide numerical data, complete text, or a combination of both.

Based on storage and recovery mechanisms: Another useful way of classifying databases is based on their method of storage and retrieval.

- ***Online databases:*** These can be accessed in real time directly from the producers of the database or through a vendor. Examples include ABI/Inform, EBSCO and Emerald.
- ***CD-ROM databases:*** Here information is available on a CD-ROM.

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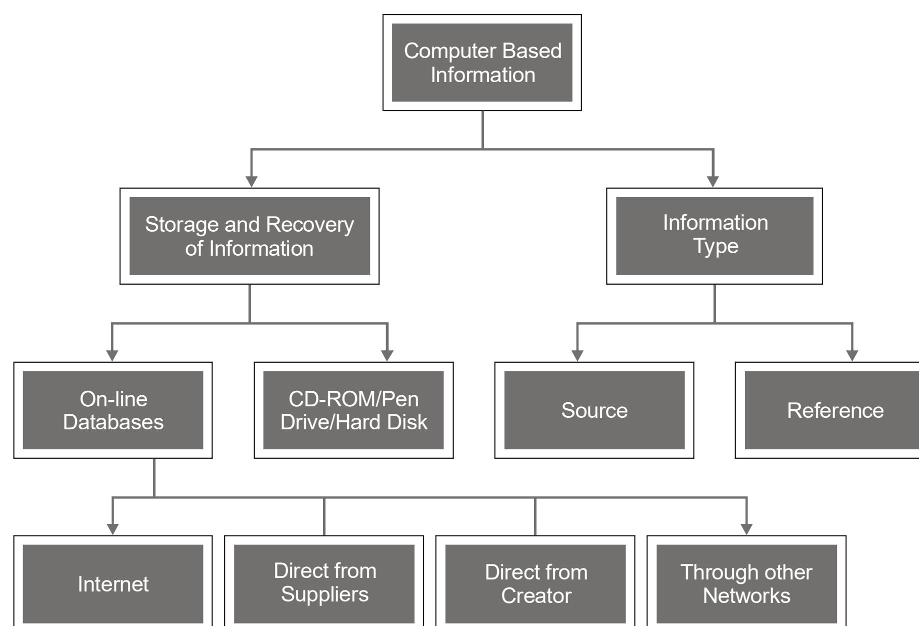


Fig. 4.3 *Classifications of Computerized Databases*

4. Syndicated data sources

Syndicated service agencies are organizations that collect organization/product-category-specific data from a regular consumer base and create a common pool of data that can be used by multiple buyers, for their individual purpose.

There are different ways to classify syndicate sources.

- **Household/individual data:** These could be in the form of surveys or panel data available through reputed agencies.
- **Surveys:** Surveys are usually one-time assessments conducted on a large representative respondent base. Like opinion polls before elections, best business school to study.
- **Product purchase panels:** These specially selected respondent groups specifically record certain identified purchases, generally related to household products and groceries.
- **Media-specific panels:** Panels are also created for collecting information related to promotion and advertising. The task of the media panel is to make use of different kinds of electronic equipment to automatically record consumer viewing behaviour. These are used to calculate the television rating performance (TRP) of different programs.
- **Scanner devices and individual source systems:** To overcome the problems of panel data, a new service is provided by research agencies through electronic scanner devices-e.g. sales volume tracking data.

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- **Institutional syndicated data:** The syndicated data can also be available at the institutional level. Retailer and wholesaler audits are examples of this kind. Usually the records are noted as:

  Beginning stocks + deliveries – ending inventory = sales for the period

Check Your Progress

1. Which type of data has a significant time and cost advantage?
2. How is secondary information collected helpful in for primary data collection instruments?
3. Cash registers are examples of which type of secondary data sources?
4. What are syndicated service agencies?

4.4 PRIMARY DATA COLLECTION: OBSERVATION METHOD

The researcher has available to him/her a wide variety of data collection methods which are primary or problem specific in nature. However in this unit we would be discussing the major and most often used methods like the observation method, focus group discussion and interview method. The questionnaire method is the most commonly used method of primary data collection. We will focus on the questionnaire method in detail in Unit 6. Let us discuss some of the other widely used methods now.

Observation is a direct method of collecting primary data. It is one of the most appropriate methods to use in case of descriptive research. The method of observation involves viewing and recording individuals, groups, organizations or events in a scientific manner in order to collect valuable data related to the topic under study.

The mode of observation could be in a standardized or *structured observation*. Here, the nature of content to be recorded, the format and the broad areas of recording are predetermined. Thus, the observer's bias is reduced and the authenticity and reliability of the information collected is higher. For example, Fisher Price toys carry out an observational study whenever they come out with a new toy. The observer is supposed to record the appeal of the toy for a child.

The opposite of this is called the *unstructured observation*. Here, the observer is supposed to make a note of whatever he understands as relevant for the research study. This kind of approach is more useful in exploratory studies Since it lacks structure, the chances of observer's bias are high. An example of this is the observation of consumers at a bank, a restaurant or a doctor's clinic.

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However, it is critical here to understand that the researcher must have a preconceived plan to capture the observations made. It is not to be treated as a blank sheet where the observer reports what he sees. The aspects to be observed must be clearly listed as in an audit form, or they could be indicative areas on which the observation is to be made.

Another way of distinguishing observations is the level of respondent being aware of being observed or not. This might be disguised; here the observation is done without the respondent's knowledge who has no idea that he/she is being observed. This can also be done with devices like a one-way mirror or a hidden camera or a recorder. The only disadvantage is this is ethically an intrusion of an individual's right to privacy. On the other hand, the knowledge that the person is under observation can be conveyed to the respondent, and this is undisguised observation. The decision to choose one over the other depends upon the nature of the study.

The observation method can also be distinguished on the basis of the setting in which the information is being collected. This could be natural observation, which as the name suggests, is carried out in actual real life locations, for example the observations of how employees interact with each other during lunch breaks. On the other hand, it could be an artificial or simulated environment in which the respondent is to be observed. This is actively done in the armed forces where stress tests are carried out to measure an individual's tolerance level.

There is another differentiation where the observation could be done by a human observer or a mechanical device.

Human observation: As the name suggests, this technique involves observation and recording done by human observers. The task of the observer is simple and predefined in case of a structured observation study as the format and the areas to be observed and recorded are clearly defined. In an unstructured observation, the observer records in a narrative form the entire event that he has observed.

Mechanical observation: In these methods, man is replaced by machine. Some examples are

- Store cameras and cameras in banks and other service areas.
- Universal product code (UPC) scanned by electric scanners in stores.
- Psychogalvanometer, which measures galvanic skin response (GSR) or changes in the electrical resistance of the skin. Thus, the respondent could be exposed to different kinds of packaging, advertisements and product composition, to note his/her reaction to them.
- Eye-tracking equipment such as oculometers, eye cameras or eye view minuters, record the movements of the eye. The oculometer determines what the individual is looking at, while the pupilometer measures the interest of the person in the stimulus. The pupilometer measures changes in the diameter of the respondent's pupils.
- Trace analysis; in this the remains or the leftovers of the consumers' basket—like his credit card spend, his recycle bin on his computer, his garbage

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(garbology) are evaluated to measure current trends and patterns of usage and disposal.

Observational techniques are an extremely useful method of primary data collection and are always a part of the inputs, whether accompanying other techniques, like interviews, discussions or questionnaire administration, or as the prime method of data collection. However, the disadvantage which they suffer from is that they are always behaviourally driven and cannot be used to investigate the reasons or causes of the observed behaviour. Another problem is that if one is observing the occurrence of a certain phenomena, one has to wait for the event to occur. One alternative to this is to study the recordings, whether verbal, written or audio-visual, in order to formulate the study-related inferences.

4.5 PRIMARY DATA COLLECTION: FOCUS GROUP DISCUSSION

Focus group discussion (FGD) is a highly versatile and dynamic method of collecting primary data from a representative group of respondents. The process generally involves a moderator who steers the discussion on the topic under study. There are a group of carefully selected respondents who are specifically invited and gathered at a neutral setting. The moderator initiates the discussion and then the group carries it forward by holding a focused and an interactive discussion.

Key elements of a focus group

Size: Ideal recommended size for a group discussion is 8 to 12 members. Less than eight would not generate all the possible perspectives on the topic and the group dynamics required for a meaningful session. And more than 12 would make it difficult to get any meaningful insight.

- **Nature:** Individuals who are from a similar background—in terms of demographic and psychographic traits—must be included, otherwise disagreement might emerge as a result of other factors rather than the one under study. The other requirement is that the respondents must be similar in terms of the subject/policy/product knowledge and experience with the product under study. Moreover, the conduction of the focus group discussion must ensure that the following criteria are taken care of:
- **Acquaintance:** It has been found that knowing each other in a group discussion is disruptive and hampers the free flow of the discussion. It is recommended that the group should consist of strangers rather than subjects who know each other.
- **Setting:** The space or setting in which the discussion takes place should be as neutral, informal and comfortable as possible. In case one-way mirrors or cameras are installed, there is a need to ensure that these gadgets are not directly visible.

- **Time period:** The discussion should be held in a single setting unless there is a 'before' and 'after' design, which requires group perceptions, initially before the study variable is introduced; and later in order to gauge the group's reactions. The ideal duration of conduction should not exceed an hour and a half. This is usually preceded by a short rapport formation session between the moderator and the group members.
- **The recording:** This is most often machine recording even though sometimes this may be accompanied by human recording as well.
- **The moderator:** The moderator is the one who manages the discussion. He might be a participant in the group discussion or he might be a non-participant. He must be a good listener and unbiased in his conduct of the discussions.

Steps in planning and conducting focus groups

The focus group conduction has to be done in a stepwise manner:

- Clearly define and enlist the research objectives of the study that requires group discussion.
- A comprehensive moderator's structured outline for conducting the whole process needs to be charted out.
- After this, the actual focus group discussion is carried out.
- The focus summary of the findings are clubbed under different heads as indicated in the focus group objectives and reported in a narrative form. This may include expressions like 'majority of the participants were of the view' or 'there was a considerable disagreement on this issue'.

Types of focus groups

The researcher has different kinds of group discussion methods available to him or her. These are:

- **Two-way focus group:** Here one respondent group sits and listens to the other and after learning from them or understanding the needs of the group, they carry out a discussion amongst themselves. For example, in a management school, the faculty group could listen to the opinions and needs of the student group.
- **Dual-moderator group:** Here, there are two different moderators; one responsible for the overt task of managing the group discussion and the other for the second objective of managing the 'group mind' in order to maximize the group performance.
- **Fencing-moderator group:** The two moderators take opposite sides on the topic being discussed and thus, in the short time available, ensure that all possible perspectives are thoroughly explored.
- **Friendship groups:** There are situations where the comfort level of the members needs to be high so that they elicit meaningful responses. This is especially the case when a supportive peer group encourages admission about the related organizations or people/issues.

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- **Mini-groups:** These groups might be of a smaller size (usually four to six) and are usually expert groups/committees that on account of their composition are able to decisively contribute to the topic under study.
- **Creativity group:** These are usually longer than one and a half hour duration and might take the workshop mode. Here, the entire group is instructed, after which they brainstorm in smaller sub-groups. They then reassemble to present their sub-group's opinion. This might also stretch across a day or two.
- **Brand-obsessive group:** These are special respondent sub-strata who are passionately involved with a brand or product category (say, cars). They are selected, as they can provide valuable insights that can be successfully incorporated into the brand's marketing strategy.
- **Online focus group:** This is a recent addition to the methodology and is extensively used today. Here, the respondents at the designated time in a web-based chat room and enters their ID and password to log on. The discussion between the moderator and the participants is real time.

4.6 PRIMARY DATA COLLECTION: PERSONAL INTERVIEW METHOD

Personal interview is a one-to-one interaction between the investigator/interviewer and the interviewee. The purpose of the dialogue is research specific and ranges from completely unstructured to highly structured.

Uses of the interview method

The interview has varied applications in business research and can be used effectively in various stages.

- **Problem definition:** The interview method can be used right in the beginning of the study. Here, the researcher uses the method to get a better clarity about the topic under study.
- **Exploratory research:** Here because the structure is loose this method can be actively used.
- **Primary data collection:** There are situations when the method is used as a primary method of data collection, this is generally the case when the area to be investigated is high on emotional responses

The interview process

The steps undertaken for the conduction of a personal interview are somewhat similar in nature to those of a focus group discussion.

Interview objective: The information needs that are to be addressed by the instrument should be clearly spelt out as study objectives. This step includes a clear definition of the construct/variable(s) to be studied.

Interview guidelines: A typical interview may take from 20 minutes to close to an hour. A brief outline to be used by the investigator is formulated depending upon the contours of the interview.

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Structure: Based on the needs of the study, the actual interview may be unstructured, semi-structured or structured.

- *Unstructured:* This type of interview has no defined guidelines. It usually begins with a casually worded opening remark like 'so tell us/me something about yourself'. The direction the interview will take is not known to the researcher also. The probability of subjectivity is very high.
- *Semi-structured:* This has a more defined format and usually only the broad areas to be investigated are formulated. The questions, sequence and language are left to the investigator's choice. Probing is of critical importance in obtaining meaningful responses and uncovering hidden issues. After asking the initial question, the direction of the interview is determined by the respondent's initial reply, the interviewer's probes for elaboration and the respondent's answers.
- *Structured:* This format has highest reliability and validity. There is considerable structure to the questions and the questioning is also done on the basis of a prescribed sequence. They are sometimes used as the primary data collection instrument also.

Interviewing skills: The quality of the output and the depth of information collected depend upon the probing and listening skills of the interviewer. His attitude needs to be as objective as possible.

Analysis and interpretation: The information collected is not subjected to any statistical analysis. Mostly the data is in narrative form, in the case of structured interviews it might be summarized in prose form.

Types of interviews

There are various kinds of interview methods available to the researcher. In the last section we have spoken about a distinction based on the level of structure. The other classification is based on the mode of administering the interview.

Figure 4.3 presents a classification of the types of personal interview.

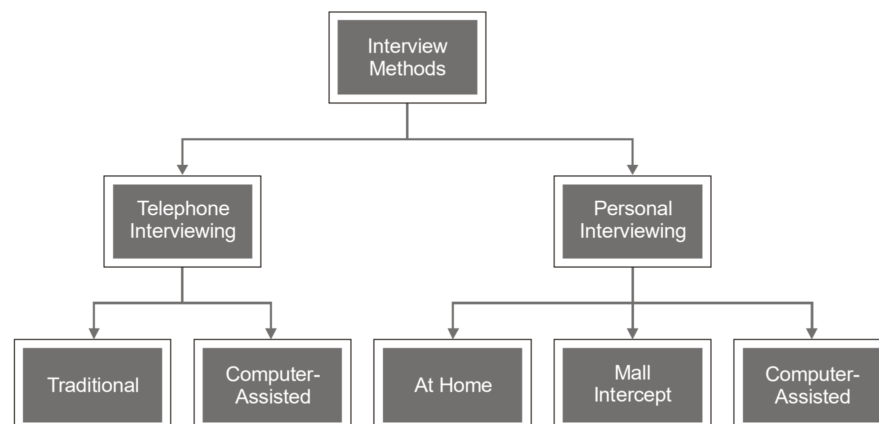


Fig. 4.3 *Types of Personal Interview*

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Personal methods: These are the traditional one-to-one methods that have been used actively in all branches of social sciences. However, they are distinguished in terms of the place of conduction.

- *At-home interviews:* This face-to-face interaction takes place at the respondent's residence. Thus, the interviewer needs to initially contact the respondent to ascertain the interview time.
- *Mall-intercept interviews:* As the name suggests, this method involves conducting interviews with the respondents as they are shopping in malls. Sometimes, product testing or product reactions can be carried out through structured methods and followed by 20–30 minute interviews to test the reactions.
- *Computer-assisted personal interviewing (CAPI):* This technique is carried out with the help of the computer. In this form of interviewing, the respondent faces an assigned computer terminal and answers a questionnaire on the computer screen by using the keyboard or a mouse. A number of pre-designed packages are available to help the researcher design simple questions that are self-explanatory and instead of probing, the respondent is guided to a set of questions depending on the answer given. There is usually an interviewer present at the time of respondent's computer-assisted interview and is available for help and guidance, if required.

Telephone method: The telephone method replaces the face-to-face interaction between the interviewer and interviewee, by calling up the subjects and asking them a set of questions. The advantage of the method is that geographic boundaries are not a constraint and the interview can be conducted at the individual respondent's location. The format and sequencing of the questions remains the same.

- *Traditional telephone interviews:* The process can be accomplished using the traditional telephone for conducting the questioning.
- *Computer-assisted telephone interviewing:* In this process, the interviewer is replaced by the computer and it involves conducting the telephonic interview using a computerized interview format. The interviewer sits in front of a computer terminal and wears a mini-headset, in order to hear the respondent answer. However, unlike the traditional method where he had to manually record the responses, the responses are simultaneously recorded on the computer.

Since the interview requires a one-to-one dialogue to be carried out, it is more cumbersome and costly as compared to a focus group discussion. Also, conduction of interview requires considerable skills on part of the interviewer and thus adequate training in interviewing skills is needed for capturing a comprehensive study-related data.

Questionnaire Method

It is one of the most cost-effective methods which can be used with considerable ease by most individual and business researchers. It has the advantage of flexibility of approach and can be successfully adapted for most research studies. The instrument has been defined differently by various researchers. Some take the traditional view of a written document requiring the subject to record his/her own responses (Kervin,1999), others have taken a broader perspective to include structured interview also as a questionnaire (Bell, 1999). It is essentially a data-collection instrument that has a pre-designed set of questions, following a particular structure (De Vaus, 2002). Since it includes a standard set of questions, it can be successfully used to collect information from a large sample in a reasonably short time period.

However, a note of caution is to be sounded here, as the usage of questionnaire as the best method in all research studies is not a foregone conclusion. For example, at the exploratory stage, when one is still trying to identify the information areas, variables and execution decision, it is advisable to use a more unstructured interview. Secondly, when the number of respondents is small and one needs to collect more subjective data and most of the questions to be asked are open-ended, then a standardized questionnaire is not advisable.

When one is designing the questionnaire, there are certain criteria that must be kept in mind.

Criteria for Questionnaire Designing

The first and foremost requirement is that the spelt-out research objectives must be converted into clear questions which will extract answers from the respondent. This is not as easy as it sounds, for example, if one wants to know something like what is the margin that a company gives to the retailer? This cannot be converted into a direct question as no one will give the correct figure. Thus, one will have to ask a disguised question like may be a range of percentage estimates—2–5 per cent, 6–10 per cent, 11–15 per cent, 16–20 per cent, etc., or the retailer might not go beyond a yes, no or ‘ industry standard’.

The second requirement is, like the Toyota questionnaire, it should be designed to engage the respondent and encourage a meaningful response. For example, a questionnaire measuring stress cannot have a voluminous set of questions which fatigue the subject. The questions, thus, should be non-threatening, must encourage response and be clear to understand. One needs to remember that the essential usage of the instrument is to administer the same to a large base, thus there must be clarity and interest that should be part of the measure itself.

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Lastly, the questions should be self-explanatory and not confusing as then the answers one gets might not be accurate or usable for analysis. This will be discussed in detail later, when we discuss the wording of the questions.

Types of questionnaire

There are many different types of questionnaire available to the researcher. The categorization can be done on the basis of a variety of parameters. The two which are most frequently used for designing purposes are the degree of construction or structure and the degree of concealment, of the research objectives. Construction or formalization refers to the degree to which the response category has been defined. Concealed refers to the degree to which the purpose of the study is explained or is clear to the respondent.

Instead of considering them as individual types, most research studies use a mixed format. Thus, they will be discussed here as a two-by-two matrix (Table 4.4).

Table 4.4 Types of Questionnaire

	FORMALIZED	NON-FORMALIZED
UNCONCEALED	Most research studies use standardized questionnaires like these	The response categories have more flexibility
CONCEALED	Used for assessing psychographic and subjective constructs	Questionnaires using projective techniques or sociometric analysis

Formalized and unconcealed questionnaire: This is the one that is indiscriminately and most frequently used by all management researchers. For example, if a new brokerage firm wants to understand the investment behaviour of the population under study, they would structure the questions and answers as follows:

1. Do you carry out any investment(s)?

   Yes __________ No __________

   If yes, continue, else terminate.

2. Out of the following options, where do you invest (tick all that apply).

   Precious metals _________, real estate __________, stocks __________, government instruments __________, mutual funds __________, any other __________.

3. Who carries out your investments?

   Myself __________, agent __________, relative __________, friend __________,

   any other __________.

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In case the option ticked is self, please go to Q. 4, else skip.

4. What is your source of information for these decisions?

   Newspaper __________, investment magazines __________, company records, etc. __________, trading portals __________, agent __________.

This kind of structured questionnaire is easy to administer, as one can see that the questions are self-explanatory and, since the answer categories are defined as well, the respondent needs to read and tick the right answer. Another advantage with this form is that it can be administered effectively to a large number of people at the same time. Data tabulation and data analysis is also easier to compute than in other methods.

This format, as a consequence of its predefined composition, is able to produce relatively stable results and is reasonably high in its reliability. The validity, of course would be limited as the comprehensive meaning of the constructs and variables under study might not be holistic when it comes to structured and limited responses. In such cases, variables are made a part of the study and some open-ended questions as well as administration/additional instructions/probing by the field investigator could help in getting better results.

Formalized and concealed questionnaire: The research studies which are trying to unravel the latent causes of behaviour cannot rely on direct questions. Thus, the respondent has to be given a set of questions that can give an indication of what are his basic values, opinions and beliefs, as these would influence how he would react to certain products or issues. For example, a publication house that wants to launch a newspaper wants to ascertain what are the general perceptions and current attitudes about newspapers. Asking a direct question would only reveal apparent information, thus, some disguised attitudinal questions would need to be asked in order to infer this.

SA – Strongly Agree; A – Agree; N – Neutral; D – Disagree; SD – Strongly Disagree

		SA	A	N	D	SD
1	The individual today is better informed about everything than before.					
2	I believe that one must live for the day and worry about tomorrow later.					
3	An individual must at all times keep abreast of what is happening in the world around him/her.					
4	Books are the best friends anyone can have.					
5	I generally read and then decide what to buy.					
6	My lifestyle is so hectic that I do not have time for reading the newspaper.					
7	The advent of radio, television and Internet have made the traditional information sources-like newspapers, redundant.					
8	A man/woman is known by what he/she reads.					

The logic behind these tests of attitude is that the questions do not seem to be in a particular direction and are apparently non-threatening, thus the respondent gives an answer which would be in the general direction of his/her attitudes.

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The advantage of these questions is that since these are structured, one can ascertain their impact and quantify the same through statistical techniques. Secondly, it has been found that psychographic questions like these increase the subject coverage and improve the validity of the instrument as well. Most studies interested in quantifying the primary response data make use of questions that are designed both as formalized unconcealed and formalized concealed.

Non-formalized unconcealed: Some researchers argue that the respondent is not really cognizant of his/her attitude towards certain things. Also, this method asks him to give structured responses to attitudinal statements that essentially express attitudes in a manner that the researcher or experts think is the correct way. This however might not be the way the person thinks. Thus, rather than giving them pre-designed response categories, it is better to give them unstructured questions where he has the freedom of expressing himself the way he wants to. Some examples of these kinds of questions are given below:

1. What has been the reason for the success of the 'lean management drive' that the organization has undertaken? Please specify FIVE most significant reasons according to YOU.
   (a) ____________________
   (b) ____________________
   (c) ____________________
   (d) ____________________
   (e) ____________________
2. Why do you think Maggi noodles are liked by young children?
   ____
3. How do you generally decide on where you are going to invest your money?
   ____
4. Give THREE reasons why you believe that the Commonwealth 2010 Games have helped the country?

The advantage of the method is that the respondent can respond in any way he/she believes is important. For example, for the last question, some people might respond by stating that it has boosted tourism in the country and contributed to the country's economy. Some might think it will encourage more international events to be held in the country. Some might also state that it is not a good idea and the government should instead be spending on improving the cause of the people who are below the poverty line.

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Thus, one gets a comprehensive perspective on what the construct/product/policy means to the population at large; and at the micro level, what it means to people in different segments. The validity of these measures is higher than the previous two. However, quantification is a little tedious and one cannot go beyond frequency and percentages to represent the findings. The other problem is the researcher's bias which might lead to clubbing responses into categories which might not be homogenous in nature.

Non-formalized, concealed: If the objective of the research study is to uncover socially unacceptable desires and latent or subconscious and unconscious motivations, the investigator makes use of questions of low structure and disguised purpose. The presumption behind this is that if the argument, the situation or question is ambiguous, it is most likely that the revelation it would result in would be more rich and meaningful. In Chapter 6, there was a discussion on projective techniques; these kinds of questionnaires are designed on the above-stated lines. The major weakness of these types of questionnaires is that being of a low structure, the interpretation required is highly skilled. Cost, time and effort are additional elements which might curtail the use of these techniques. A study conducted to measure to which segment should men's personal care toiletries (especially moisturizers and fairness creams) be targeted, the investigator designed two typical bachelors' shopping lists. One with a number of monthly grocery products as well as the normal male toiletries like shaving blades, gels, shampoos, etc., and the other list had the same grocery products and male toiletries but it had two additional items—Fair and Handsome fairness cream and sensitive skin moisturizer. The list was given to 20 young men to conceptualize/describe the person whose list this is. The answers obtained were as follows:

List with Cream and Moisturizer	List without Cream and Moisturizer
65 per cent said this person was good looking	10 per cent said this man was good looking
5 per cent said typical male	39 per cent said 30 plus in age
25 per cent said a 20-year-old	90 per cent said rugged and manly
48 per cent said has a girlfriend	38 per cent said has a girlfriend
46 per cent said has a boyfriend	No one spoke of boyfriend
26 per cent said spendthrift	21 per cent said thrifty
15 per cent said 'girly'	32 per cent said normal Indian male

Thus, as we can see, the normal Indian adult male is still going to take time to include beauty or cosmetic products into his normal personal care basket. Thus,

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it is wiser for the marketeers to target the younger metrosexual male who is a heavy spender.

Another useful way of categorizing questionnaires is on the method of administration. Thus, the questionnaire that has been prepared would necessitate a face-to-face interaction. In this case, the interviewer reads out each question and makes a note of the respondent's answers. This administration is called a *schedule*. It might have a mix of the questionnaire type as described in the section above and might have some structured and some unstructured questions. The investigator might also have a set of additional material like product prototypes or copy of advertisements. The investigator might also have a predetermined set of standardized questions or clarifications , which he can use to ask questions like 'why do you say that?' or 'can you explain this in detail' 'what I mean to ask is……' The other kind is the *self-administered questionnaire*, where the respondent reads all the instructions and questions on his own and records his own statements or responses. Thus, all the questions and instructions need to be explicit and self-explanatory.

The selection of one over the other depends on certain study prerequisites.

Population characteristics: In case the population is illiterate or unable to write the responses, then one must as a rule use the schedule, as the questionnaire cannot be effectively answered by the subject himself.

Population spread: In case the sample to be studied is large and dispersed, then one needs to use the questionnaire. Also when the resources available for the study, time, cost and manpower are limited, then schedules become expensive to use and it is advisable to use self-administered questionnaire.

Study area: In case one is studying a sensitive topic , like organizational climate or quality of working life, where the presence of an investigator might skew the answers in a more positive direction, then it is better that one uses the questionnaire. However, in case the motives and feelings are not well-developed and structured, one might need to do additional probing and in that case a schedule is better. If the objective is to explore concepts or trace the reaction of the sample population to new ideas and concepts, a schedule is advisable.

Check Your Progress

5. What is the consequence of standardized or structured observation?
6. Define a facing-moderator group.
7. In which structure of interview is the probability of subjectivity very high?

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4.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The secondary type of data has a significant time and cost advantage.
2. The secondary information collected can be used to design the primary data collection instruments, in order to phrase and design the right questions.
3. Cash registers are examples of sales data type of secondary data sources.
4. Syndicated service agencies are organizations that collect organization/ product-category-specific data from a regular consumer base and create a common pool of data that can be used by multiplier buyers, for their individual purpose.
5. The consequence of standardized or structured observation is that the observer's bias is reduced, and the authenticity and reliability of the information collected is higher.
6. A facing-moderator group is a type of focus group in which the two moderators take opposite sides on the topic being discussed and thus, in the short time available, ensure that all possible perspectives are thoroughly explored.
7. In the unstructured interview the probability of subjectivity very high.

4.8 SUMMARY

- The researcher has access to two major sources of this data: original as in primary sources or secondary data.
- The secondary information is useful, fast and cost-effective way of testing and achieving the study objectives.
- Secondary data could be collected and compiled within the organization/ industry.
- Data collected from an outside source is termed as external data source.
- The observational method is the simplest method of primary data collection. This can be differentiated into structure-unstructured; human – mechanically observed data.
- The focus group discussion is a cost effective method and can ideally be done on a small group of respondents to obtain meaningful data.
- Interview method involves a dialogue between the interviewee and the interviewer. This can range from unstructured to completely structured.

Today the interviewer can make use of the telephone as well as computer to assist him in conducting the interview.

4.9 KEY WORDS

- **External source of data:** Information that is collected and compiled by an outside source that is external to the organization.
- **Focus group discussion:** A form of structured group discussion involving people with knowledge and interest in a particular topic and a facilitator.
- **Online database:** a *database* that can be accessed by computers.
- **Primary data:** Original, problem or project-specific and collected for the specific objectives and needs spelt out by the researcher.
- **Secondary data:** Information which is not topical or research-specific and has been collected and compiled by some other researcher or investigative body.
- **Syndicated data:** Information gathered by a service or company for public release and sold by subscription.

4.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Distinguish between secondary and primary methods of data collection.
2. Explain the interview method of data collection.
3. What are the advantages and disadvantages of secondary data?

Long-Answer Questions

1. How can secondary data be classified? Elaborate on each type with suitable examples.
2. What is the observation method? What are the different types of observation methods available to the researcher?
3. What are focus group discussions? What are the types of focus groups available to the researcher?
4. What are the uses of the technique? What are the different types of interviews?

4.11 FURTHER READINGS

NOTES

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BLOCK - III
METHODOLOGY

NOTES

UNIT 5 ATTITUDE MEASUREMENT AND SCALING

Structure

5.0 INTRODUCTION

In the previous unit, we studied the various types, sources and methods of collecting data. In this unit, we will focus on different types of measurements and the statistical techniques that are applicable for the same. The various formats of a rating scale and the construction of the attitude measurement scale, along with the description of the distinct criteria involved in analysing a good measurement scale, are elaborated in this unit.

The term 'measurement' means assigning numbers or some other symbols to the characteristics of certain objects. When numbers are used, the researcher must have a rule for assigning a number to an observation in a way that provides an accurate description. We do not measure the object but some characteristics of it. Therefore, in research, people/consumers are not measured; what is measured only are their perceptions, attitude or any other relevant characteristics. There are two reasons for which numbers are usually assigned. First of all, numbers permit statistical analysis of the resulting data and secondly, they facilitate the communication of measurement results.

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Scaling is an extension of measurement. Scaling involves creating a continuum on which measurements on objects are located. Suppose you want to measure the satisfaction level towards Kingfisher Airlines and a scale of 1 to 11 is used for the said purpose. This scale indicates the degree of dissatisfaction, with 1 = extremely dissatisfied and 11 = extremely satisfied.

5.1 OBJECTIVES

After going through this unit, you will be able to:

- Define measurement
- Distinguish between the four types of measurement scales
- Define attitude and its three components
- Discuss the various classifications of scales
- Define measurement error and explain the criteria for good measurement

5.2 TYPES OF MEASUREMENT SCALES

There are four types of measurement scales—nominal, ordinal, interval and ratio. We will discuss each one of them in detail. The choice of the measurement scale has implications for the statistical technique to be used for data analysis.

Nominal scale: This is the lowest level of measurement. Here, numbers are assigned for the purpose of identification of the objects. Any object which is assigned a higher number is in no way superior to the one which is assigned a lower number. Each number is assigned to only one object and each object has only one number assigned to it. It may be noted that the objects are divided into mutually exclusive and collectively exhaustive categories.

Example:

- What is your religion?
  (a) Hinduism
  (b) Sikhism
  (c) Christianity
  (d) Islam
  (e) Any other, (please specify)

A Hindu may be assigned a number 1, a Sikh may be assigned a number 2, a Christian may be assigned a number 3 and so on. Any religion which is assigned a higher number is in no way superior to the one which is assigned a lower number. The assignment of numbers is only for the purpose of identification.

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Nominal scale measurements are used for identifying food habits (vegetarian or non-vegetarian), gender (male/female), caste, respondents, marital status, brands, attributes, stores, the players of a hockey team and so on.

The assigned numbers cannot be added, subtracted, multiplied or divided. The only arithmetic operations that can be carried out are the count of each category. Therefore, a frequency distribution table can be prepared for the nominal scale variables and mode of the distribution can be worked out. One can also use chi-square test and compute contingency coefficient using nominal scale variables.

Ordinal scale: This is the next higher level of measurement than the nominal scale measurement. One of the limitations of the nominal scale measurements is that we cannot say whether the assigned number to an object is higher or lower than the one assigned to another option. The ordinal scale measurement takes care of this limitation. An ordinal scale measurement tells whether an object has more or less of characteristics than some other objects. However, it cannot answer how much more or how much less.

Example:

- Rank the following attributes while choosing a restaurant for dinner. The most important attribute may be ranked one, the next important may be assigned a rank of 2 and so on.

Attribute	Rank
Food quality	
Prices	
Menu variety	
Ambience	
Service	

In the ordinal scale, the assigned ranks cannot be added, multiplied, subtracted or divided. One can compute median, percentiles and quartiles of the distribution. The other major statistical analysis which can be carried out is the rank order correlation coefficient, sign test. All the statistical techniques which are applicable in the case of nominal scale measurement can also be used for the ordinal scale measurement. However, the reverse is not true. This is because ordinal scale data can be converted into nominal scale data but not the other way round.

Interval scale: The interval scale measurement is the next higher level of measurement. It takes care of the limitation of the ordinal scale measurement where the difference between the score on the ordinal scale does not have any meaningful interpretation. In the interval scale the difference of the score on the scale has meaningful interpretation. It is assumed that the respondent is able to answer the

questions on a continuum scale. The mathematical form of the data on the interval scale may be written as

$$Y = a + b\,X \qquad \text{Where } a \neq 0$$

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In the interval scale, the difference in score has a meaningful interpretation while the ratio of the score on this scale does not have a meaningful interpretation. This can be seen from the following interval scale question:

- How likely are you to buy a new designer carpet in the next six months?

	Very unlikely	**Unlikely**	**Neutral**	**Likely**	**Very likely**
Scale A	1	2	3	4	5
Scale B	0	1	2	3	4
Scale C	–2	–1	0	1	2

Suppose a respondent ticks the response category 'likely' and another respondent ticks the category 'unlikely'. If we use any of the scales A, B or C, we note that the difference between the scores in each case is 2. Whereas, when the ratio of the scores is taken, it is 2, 3 and –1 for the scales A, B and C respectively. Therefore, the ratio of the scores on the scale does not have a meaningful interpretation. The following are some examples of interval scale data.

- How important is price to you while buying a car?

Least important	Unimportant	Neutral	Important	Most important
1	2	3	4	5

- How do you rate the work environment of your organization?

Very good	Good	Neither good nor bad	Bad	Very bad
5	4	3	2	1

- How expensive is the restaurant 'Punjabi By Nature'?

Extremely expensive	Definitely expensive	Somewhat expensive	Somewhat inexpensive	Definitely inexpensive	Extremely inexpensive
1	2	3	4	5	6

The numbers on this scale can be added, subtracted, multiplied or divided. One can compute arithmetic mean, standard deviation, correlation coefficient and conduct a t-test, Z-test, regression analysis and factor analysis. As the interval scale data can be converted into the ordinal and the nominal scale data, therefore all the techniques applicable for the ordinal and the nominal scale data can also be used for interval scale data.

Ratio scale: This is the highest level of measurement and takes care of the limitations of the interval scale measurement, where the ratio of the measurements on the scale does not have a meaningful interpretation. The ratio scale measurement can be converted into interval, ordinal and nominal scale. But the other way round is

not possible. The mathematical form of the ratio scale data is given by $Y = b X$. In this case, there is a natural zero (origin), whereas in the interval scale we had an arbitrary zero. Examples of the ratio scale data are weight, distance travelled, income and sales of a company, to mention a few.

All the mathematical operations can be carried out using the ratio scale data. In addition to the statistical analysis mentioned in the interval, the ordinal and the nominal scale data, one can compute coefficient of variation, geometric mean and harmonic mean using the ratio scale measurement.

5.2.1 Attitude

An attitude is viewed as an enduring disposition to respond consistently in a given manner to various aspects of the world, including persons, events and objects. A company is able to sell its products or services when its customers have a favourable attitude towards its products/services. In the reverse scenario, the company will not be able to sustain itself for long. It, therefore, becomes very important to measure the attitude of the customers towards the company's products/services. Unfortunately, attitude cannot be measured directly. In order to measure an attitude, we make an inference based on the perceptions the customers have about the product/services. The attitude is derived from the perceptions. If the consumers have a favourable perception towards the products/services, the attitude will be favourable. Therefore, the attitudes are indirectly observed.

Basically, attitude has three components: cognitive, affective and intention (or action) components.

Cognitive component: This component represents an individual's information and knowledge about an object. It includes awareness of the existence of the object, beliefs about the characteristics or attributes of the object and judgement about the relative importance of each of the attributes. In a survey, if the respondents are asked to name the companies manufacturing plastic products, some respondents may remember names like Tupperware, Modicare and Pearl Pet. This is called unaided recall awareness. More names are likely to be remembered when the investigator makes a mention of them. This is aided recall. The examples of beliefs or judgements could be that the products of Tupperware are of high quality, non-toxic and can be used in parties; a mutton dish can be cooked in a pressure cooker in less than 30 minutes and so on.

Affective component: The affective component summarizes a person's overall feeling or emotions towards the objects. The examples for this component could be: the food cooked in a pressure cooker is tasty, taste of orange juice is good or the taste of bitter gourd is very bad.

Intention or action component: This component of an aptitude, also called the behavioural component, reflects a predisposition to an action by reflecting the consumer's buying or purchase intention. It also reflects a person's expectations of future behaviour towards an object.

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There is a relationship between attitude and behaviour. If a consumer does not have a favourable attitude towards the product, he/she will certainly not buy the product. However, having a favourable attitude does not mean that it would be reflected in the purchase behaviour. This is because intention to buy a product has to be backed by the purchasing power of the consumer. Therefore, the relationship between the attitude and the purchase behaviour is a necessary condition for the purchase of the product but it is not a sufficient condition. This relationship could hold true at the aggregate level but not at the individual level.

Check Your Progress

1. State the limitation of nominal scale which is taken care of by the ordinal scale.
2. What is the highest level of measurement?
3. Define the intention component of attitude.

5.3 CLASSIFICATION OF SCALES

One of the ways of classifications of scales is in terms of the number of items in the scale. Based upon this, the following classification may be proposed:

5.3.1 Single Item vs Multiple Item Scale

Single item scale: In the single item scale, there is only one item to measure a given construct. For example:

Consider the following question:

- How satisfied are you with your current job?

  Very Dissatisfied

  Dissatisfied

  Neutral

  Satisfied

  Very satisfied

The problem with the above question is that there are many aspects to a job, like pay, work environment, rules and regulations, security of job and communication with the seniors. The respondent may be satisfied on some of the factors but may not on others. By asking a question as stated above, it will be difficult to analyse the problem areas. To overcome this problem, a multiple item scale is proposed.

Multiple item scale: In multiple item scale, there are many items that play a role in forming the underlying construct that the researcher is trying to measure. This is because each of the item forms some part of the construct (satisfaction) which the researcher is trying to measure. As an example, some of the following questions may be asked in a multiple item scale.

- How satisfied are you with the pay you are getting on your current job?

  Very dissatisfied

  Dissatisfied

  Neutral

  Satisfied

  Very satisfied

- How satisfied are you with the rules and regulations of your organization?

  Very dissatisfied

  Dissatisfied

  Neutral

  Satisfied

  Very satisfied

5.3.2 Comparative vs Non-comparative Scales

The scaling techniques used in research can also be classified into comparative and non-comparative scales (Figure 5.1).

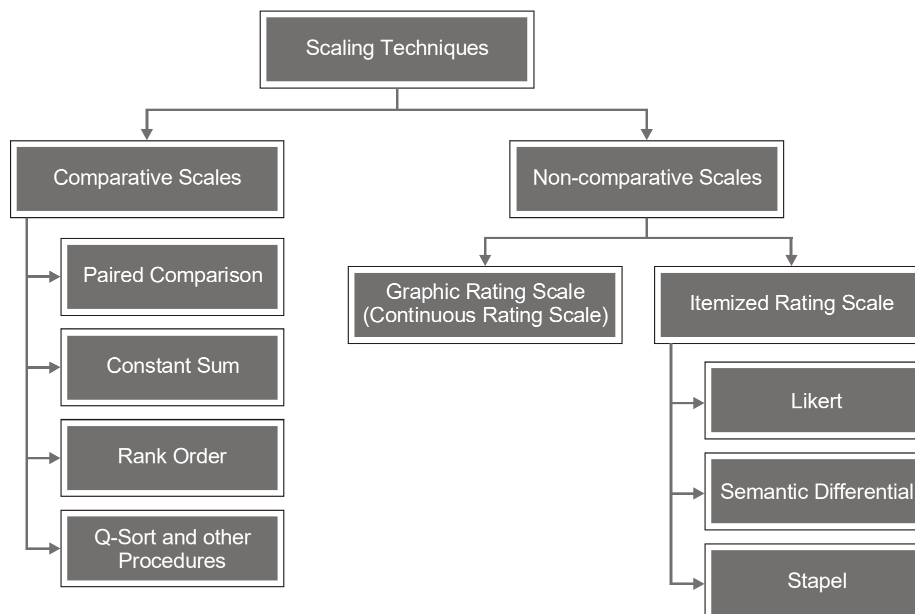


Fig. 5.1 *Types of Scaling Techniques*

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Comparative scales

In comparative scales it is assumed that respondents make use of a standard frame of reference before answering the question. For example:

A question like 'How do you rate Barista in comparison to Cafe Coffee Day on quality of beverages?' is an example of the comparative rating scale. It involves the direct comparison of stimulus objects. Example:

- Please rate Domino's in comparison to Pizza Hut on the basis of your satisfaction level on an 11-point scale, based on the following parameters: (1 = Extremely poor, 6 = Average, 11 = Extremely good). Circle your response:

a.	Variety of menu options	1	2	3	4	5	6	7	8	9	10	11
b.	Value for money	1	2	3	4	5	6	7	8	9	10	11
c.	Speed of service (delivery time)	1	2	3	4	5	6	7	8	9	10	11
d.	Promotional offers	1	2	3	4	5	6	7	8	9	10	11
e.	Food quality	1	2	3	4	5	6	7	8	9	10	11

Comparative scale data is interpreted generally in a relative kind. Below are discussed each of the scale under comparative rating scales in detail below:

Paired comparison scales: Here a respondent is presented with two objects and is asked to select one according to whatever criterion he or she wants to use. The resulting data from this scale is ordinal in nature. As an example, suppose a parent wants to offer one of the four items to a child—chocolate, burger, ice cream and pizza. The child is offered to choose one out of the two from the six possible pairs, i.e., chocolate or burger, chocolate or ice cream, chocolate or pizza, burger or ice cream, burger or pizza and ice cream or pizza. In general, if there are n items, the number of paired comparison would be $(n(n-1)/2)$. Paired comparison technique is useful when the number of items is limited because it requires a direct comparison and overt choice.

Rank order scaling: In the rank order scaling, respondents are presented with several objects simultaneously and asked to order or rank them according to some criterion. Consider, for example the following question:

- Rank the following soft drinks in order of your preference, the most preferred soft drink should be ranked one, the second most preferred should be ranked two and so on.

Soft Drinks	Rank
Coke	
Pepsi	
Limca	
Sprite	
Mirinda	
Seven Up	
Fanta	

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Like paired comparison, this approach is also comparative in nature. The problem with this scale is that if a respondent does not like any of the above-mentioned soft drink and is forced to rank them in the order of his choice, then, the soft drink which is ranked one should be treated as the least disliked soft drink and similarly, the other rankings can be interpreted. The rank order scaling results in the ordinal data.

Constant sum rating scaling: In constant sum rating scale, the respondents are asked to allocate a total of 100 points between various objects and brands. The respondent distributes the points to the various objects in the order of his preference. Consider the following example:

- Allocate a total of 100 points among the various schools into which you would like to admit your child. The points should be allocated in such a way that the sum total of the points allocated to various schools adds up to 100.

Schools	Points
DPS	
Mother's International	
APEEJAY	
DAV Public School	
Laxman Public School	
TOTAL POINTS	**100**

Suppose Mother's International is awarded 30 points, whereas Laxman Public School is awarded 15 points, one can make a statement that the respondent rates Mother's International twice as high as Laxman Public School. This type of data is not only comparative in nature but could also result in ratio scale measurement.

Q-sort technique: This technique makes use of the rank order procedure in which objects are sorted into different piles based on their similarity with respect to certain criterion. Suppose there are 100 statements and an individual is asked to pile them into five groups, in such a way, that the strongly agreed statements could be put in one pile, agreed statements could be put in another pile, neutral statement form the third pile, disagreed statements come in the fourth pile and strongly disagreed statements form the fifth pile, and so on. The data generated in this way would be ordinal in nature. The distribution of the number of statement in each pile should be such that the resulting data may follow a normal distribution.

Non-comparative scales

In the non-comparative scales, the respondents do not make use of any frame of reference before answering the questions. The resulting data is generally assumed to be interval or ratio scale.

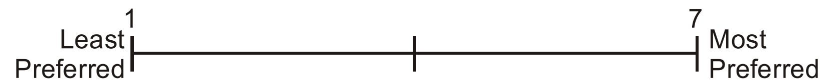
The non-comparative scales are divided into two categories, namely, the graphic rating scales and the itemized rating scales. A useful and widely used itemized rating scale is the Likert scale.

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Graphic rating scale

This is a continuous scale, also called graphic rating Scale. In the graphic rating scale the respondent is asked to tick his preference on a graph. Consider for example the following question:

- Please put a tick mark (✓) on the following line to indicate your preference for fast food.



To measure the preference of an individual towards the fast food one has to measure the distance from the extreme left to the position where a tick mark has been put. Higher the distance, higher would be the individual preference for fast food. This scale suffers from two limitations—one, if a respondent has put a tick mark at a particular position and after ten minutes, he or she is given another form to put a tick mark, it will virtually be impossible to put a tick at the same position as was done earlier. Does it mean that the respondent's preference for fast food has undergone a change in 10 minutes? The basic assumption in this scale is that the respondents can distinguish the fine shade in differences between the preference/attitude which need not be the case. Further, the coding, editing and tabulation of data generated through such a procedure is a very tedious task and researchers try to avoid using it.

Itemized rating scale

In the itemized rating scale, the respondents are provided with a scale that has a number of brief descriptions associated with each of the response categories. The response categories are ordered in terms of the scale position and the respondents are supposed to select the specified category that describes in the best possible way an object is rated. There are certain issues that should be kept in mind while designing the itemized rating scale. These issues are:

Number of categories to be used: There is no hard and fast rule as to how many categories should be used in an itemized rating scale. However, it is a practice to use five or six categories. Some researches are of the opinion that more than five categories should be used in situations where small changes in attitudes are to be measured. There are others that argue that the respondents would find it difficult to distinguish between more than five categories.

Odd or even number of categories: It has been a matter of debate among the researchers as to whether odd or even number of categories are to be used. By using even number of categories the scale would not have a neutral category and the respondent will be forced to choose either the positive or the negative side of the attitude. If odd numbers of categories are used, the respondent has the freedom to be neutral if he wants to be so.

Balanced versus unbalanced scales: A balanced scale is the one which has equal number of favourable and unfavourable categories. The following is the example of a balanced scale:

- How important is price to you in buying a new car?

  Very important

  Relatively important

  Neither important nor unimportant

  Relatively unimportant

  Very unimportant

In this question, there are five response categories, two of which emphasize the importance of price and two others that do not show its importance. The middle category is neutral.

The following is the example of the unbalanced scale.

- How important is price to you in buying a new car?

  More important than any other factor

  Extremely important

  Important

  Somewhat important

  Unimportant

In this question there are four response categories that are skewed towards the importance given to the price, whereas one category is for the unimportant side. Therefore, this question is an unbalanced question.

Nature and degree of verbal description: Many researchers believe that each category must have a verbal, numerical or pictorial description. Verbal description should be clearly and precisely worded so that the respondents are able to differentiate between them. Further, the researcher must decide whether to label every scale category, some scale categories, or only extreme scale categories.

Forced versus non-forced scales: In the forced scale, the respondent is forced to take a stand, whereas in the non-forced scale, the respondent can be neutral if he/she so desires. The argument for a forced scale is that those who are reluctant to reveal their attitude are encouraged to do so with the forced scale. Paired comparison scale, rank order scale and constant sum rating scales are examples of forced scales.

Physical form: There are many options that are available for the presentation of the scales. It could be presented vertically or horizontally. The categories could be expressed in boxes, discrete lines or as units on a continuum. They may or may not have numbers assigned to them. The numerical values, if used, may be positive, negative or both.

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Suppose we want to measure the perception about Jet Airways using a multi-item scale. One of the questions is about the behaviour of the crew members. Given below is a set of scale configurations that may be used to measure their behaviour.

The behaviour of the crew members of Jet Airways is:

1.	Very bad	_____	_____	_____	_____	_____	Very good
2.	Very bad	1	2	3	4	5	Very good
3.	–2	–1	0	1	2		
	Very bad	Neither bad nor good					Very good

Below we will describe Likert scale, which is very commonly used in survey research.

Likert scale: This is a multiple item agree–disagree five-point scale. The respondents are given a certain number of items (statements) on which they are asked to express their degree of agreement/disagreement. This is also called a summated scale because the scores on individual items can be added together to produce a total score for the respondent. An assumption of the Likert scale is that each of the items (statements) measures some aspect of a single common factor, otherwise the scores on the items cannot legitimately be summed up. In a typical research study, there are generally 25–30 items on a Likert scale.

To construct a Likert scale to measure a particular construct, a large number of statements pertaining to the construct are listed. These statements could range from 80–120. The identification of the statements is done through exploratory research which is carried out by conducting a focus group, unstructured interviews with knowledgeable people, literature survey, analysis of case studies and so on. Suppose we want to assess the image of a company. As a first step, an exploratory research may be conducted by having an informal interview with the customers, and employees of the company. The general public may also be contacted. A survey of the literature on the subject may also give a set of information that could be useful for constructing the statements. Suppose the number of statements to measure the constructs is 100 in number. Now samples of representative respondents are asked to state their degree of agreement/disagreement on those statements. Table 5.1 gives a few statements to assess the image of the company.

It may be noted that only anchor labels and no numerical values are assigned to the response categories. Once the scale is administered, numerical values are assigned to the response categories. The scale contains statements' some of which are favourable to the construct we are trying to measure and some are unfavourable to it.

For example, out of the ten statements given, statements numbering 1, 2, 4, 6 and 9 in Table 5.1 are favourable statements, whereas the remaining are unfavourable statements. The reason for having a mixture of favourable and unfavourable statements in a Likert scale is that the responses by the respondent

should not become monotonous while answering the questions. Generally, in a Likert scale, there is an approximately equal number of favourable and unfavourable statements. Once the scale is administered, numerical values are assigned to the responses. The rule is that a 'strongly agree' response for a favourable statement should get the same numerical value as the 'strongly disagree' response of the unfavourable statement. Suppose for a favourable statement the numbering is done as Strongly disagree = 1, Disagree = 2, Neither agree nor disagree = 3, Agree = 4 and Strongly agree = 5. Accordingly, an unfavourable statement would get the numerical values as Strongly disagree = 5, Disagree = 4, Neither agree nor disagree = 3, Agree = 2 and Strongly agree = 1. In order to measure the image that the respondent has about the company, the scores are added.

Table 5.1 *Likert Scale Statements to Measure the Image of the Company*

No.	Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1.	The company makes quality products			✓		
2.	It is a leader in technology					✓
3.	It doesn't care about the general public.		✓			
4.	The company leads in R&D to improve products				✓	
5.	The company is not a good paymaster.	✓				
6.	The products of the company go through stringent quality tests.				✓	
7.	The company has not done anything to curb pollution.		✓			
8.	It does not care about the community near its plant.	✓				
9.	The company's stocks are good to buy or own.				✓	
10.	The company does not have good labour relations.		✓			

For example, if a respondent has ticked (✓) statements numbering from one to ten as shown in Table 5.1, his total score would be 3 + 5 + 4 + 4 + 5 + 4 + 4 + 5 + 4 + 4 = 42 out of 50. Now if there are 100 respondents and 100 statements, the score on the image of the company can be worked out for each respondent by adding his/her scores on the 100 statements. The minimum score for each respondent will be 100, whereas the maximum score would be 500.

As mentioned earlier, a typical Likert scale comprises about 25–30 statements. In order to select 25 statements from the 100 statements, we need to discard some of them. The rule behind discarding the statements is that those items that are non-discriminating should be removed. The procedure for choosing 25 (say number of statements) is shown.

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As mentioned earlier, the score for each of the respondents on each of the statements can be used to measure his/her total score about the image of the company. The data may look as given in Table 5.2.

Table 5.2 *Total Score and Individual Score of Each Respondent on Various Statements*

	Scores of Statements									
Resp. No.	**1**	**2**	**3**	**..........**	**i**	**..........**	**j**	**...........**	**100**	**Total Score**
1	-	-	-	....	5	....	4	....	-	410
2	-	-	-	....	4	....	2	....	-	209
3	-	-	-	....	-	....	-	....	-	-
-	-	-	-	....	-	....	-	....	-	-
100	-	-	-	....	-	....	-	....	-	-

Table 5.2 shows that the total score for respondent no. 1 is 410, whereas for respondent no. 2 it is 209. This means that respondent no. 1 has a more favourable image for the company as compared to respondent no. 2. Now, in order to select 25 statements, let us consider statements numbering i and j. We note that the statement no. j is more discriminating as compared to statement no. i. This is because the score on statement j is very highly correlated with the total score as compared to the scores on statement i. Therefore, if we have to choose between i and j, we will choose statement no. j. From this we can conclude that only those statements will be selected which have a very high correlation with the total score. Therefore, the 100 correlations are to be arranged in the descending order of magnitudes corresponding to each statement and only top 25 statements having a high correlation with the total score need to be selected.

Check Your Progress

4. What is the Q-sort technique?
5. Give some examples of forced scales.
6. Why is the Likert scale also called a summated scale?

5.4 MEASUREMENT ERROR

Measurement error occurs when the observed measurement on a construct or concept deviates from its true values. The following is a list of the sources of measurement errors.

- There are factors like mood, fatigue and health of the respondent which may influence the observed response while the instrument is being administered. The other factors could be education, job, awareness of topic and reluctance to express an opinion.

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- The variations in the environment in which measurements are taken may also result in a departure from the true value.
- At times, the errors may be committed at the time of coding, entering of data from questionnaire to the spreadsheet on the computer and at the tabulation stage. The other reasons could be defective instrument for data collection like lengthy and ambiguous questionnaire with leading questions (suggestive responses) in the instrument.

The observed measurement in any research need not be equal to the true measurement. The observed measurement can be written as

$$O = T + S + R$$

Where, O = Observed measurement

T = True score

S = Systematic error

R = Random error

It may be noted that the total error consists of two components—systematic error and random error. Systematic error causes a constant bias in the measurement. Suppose there is a weighing scale that weighs 50 gm less for every one kg of product being weighed. The error would consistently remain the same irrespective of the kind of product and the time at which product is weighed. Random error on the other hand involves influences that bias the measurements but are not systematic. Suppose we use different weighing scales to weigh one kg of a product and if systematic error is assumed to be absent, we may find that recorded weights may fall within a range around the true value of the weight, thereby causing random error.

5.4.1 Criteria for Good Measurement

There are three criteria for evaluating measurements: reliability, validity and sensitivity. It may be noted that there is a relationship between reliability and sensitivity. If we want to make an item more sensitive, it may be achieved at the cost of reliability. This means to get more sensitivity, the researcher might have to compromise with reliability.

1. Reliability

Reliability is concerned with consistency, accuracy and predictability of the scale. It refers to the extent to which a measurement process is free from random errors. The reliability of a scale can be measured using the following methods:

Test–retest reliability: In this method, repeated measurements of the same person or group using the same scale under similar conditions are taken. A very high correlation between the two scores indicates that the scale is reliable. The researcher has to be careful in deciding the time difference between two observations. If the time difference between two observations is very small it is very likely that the respondent would give same answer which could result in higher correlation. Further

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if the difference is too large, the attitude might have undergone a change during that period, resulting in a weak correlation and hence poor reliability. Therefore researcher have to be very careful in deciding the time difference between observation. Generally, a time difference of about 5-6 months is considered as an ideal period.

Split-half reliability method: This method is used in the case of multiple item scales. Here the number of items is randomly divided into two parts and a correlation coefficient between the two is obtained. A high correlation indicates that the internal consistency of the construct leads to greater reliability.

2. Validity

The validity of a scale refers to the question whether we are measuring what we want to measure. Validity of the scale refers to the extent to which the measurement process is free from both systematic and random errors. The validity of a scale is a more serious issue than reliability. There are different ways to measure validity.

Content validity: This is also called face validity. It involves subjective judgement by an expert for assessing the appropriateness of the construct. For example, to measure the perception of a customer towards Kingfisher Airlines, a multiple item scale is developed. A set of 15 items is proposed. These items when combined in an index measure the perception of Kingfisher Airlines. In order to judge the content validity of these 15 items, a set of experts may be requested to examine the representativeness of the 15 items. The items covered may be lacking in the content validity if we have omitted behaviour of the crew, food quality, and food quantity, etc., from the list. In fact, conducting the exploratory research to exhaust the list of items measuring perception of the airline would be of immense help in such a case.

Predictive validity: This involves the ability of a measured phenomena at one point of time to predict another phenomenon at a future point of time. If the correlation coefficient between the two is high, the initial measure is said to have a high predictive ability. As an example, consider the use of the common admission test (CAT) to shortlist candidates for admission to the MBA programme in a business school. The CAT scores are supposed to predict the candidate's aptitude for studies towards business education.

3. Sensitivity

Sensitivity refers to an instrument's ability to accurately measure the variability in a concept. A dichotomous response category such as agree or disagree does not allow the recording of any attitude changes. A more sensitive measure with numerous categories on the scale may be required. For example, adding 'strongly agree', 'agree', 'neither agree nor disagree', 'disagree and 'strongly disagree' categories will increase the sensitivity of the scale.

The sensitivity of scale based on a single question or a single item can be increased by adding questions or items. In other words, because composite measures allow for a greater range of possible scores, they are more sensitive than a single-item scale.

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Check Your Progress

7. What are systematic errors?
8. Name the method in which the number of items is randomly divided into two parts and a correlation coefficient between the two is obtained.

5.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. One of the limitation of the nominal scale measurements is that we cannot say whether the assigned number to an object is higher or lower than the one assigned to another option. The ordinal scale measurement takes care of this limitation.
2. The highest level of measurement is the ratio scale.
3. The intention component of attitude also called the behavioural component, reflects a predisposition to an action by reflecting the consumer's buying or purchase intention.
4. The Q-sort technique makes use of the rank order procedure in which objects are sorted into different piles based on their similarity with respect to certain criterion.
5. Some examples of forced scales include paired comparison scale, rank order scale and constant sum rating scales.
6. The Likert scale is also called as summated scale because the scores on individual items can be added together to produce a total score for the respondent.
7. Systematic errors are one of the components of total error which causes a constant bias in the measurement.
8. Split-half reliability method is the method in which the number of items is randomly divided into two parts and a correlation between the two is obtained.

5.6 SUMMARY

- Measurement means the assignment of numbers or other symbols to the characteristics of certain objects. Scaling is an extension of measurement. Scaling involves creating a continuum on which measurements on the objects are located. There are four types of measurement scales: nominal, ordinal, interval and ratio scale.

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- Attitude is a predisposition of the individual to evaluate some objects or symbol. Attitude has three components: cognitive, affective and intention or action component.
- Scales can be classified as single-item and multiple-item scales. Another classification could be whether the scales are comparative or non-comparative in nature.
- The observed measurement need not be equal to the true value of the measurement. Some systematic and random errors may be found in the observed measurement. There are three criteria for determining the accuracy of a measurement—reliability, validity and sensitivity.

5.7 KEY WORDS

- **Balanced scale:** A scale that has equal number of favourable and unfavourable categories.
- **Comparative scale:** A scale in which respondents make use of some standard frame of reference before answering the question.
- **Forced scale: A scale** in which the respondent is forced to take a stand
- **Interval scale:** A scale that makes use of an arbitrary origin.
- **Validity:** It deals with whether a scale measures what it is supposed to measure.

5.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is the meaning of measurement in research? Give examples.
2. Outline the steps involved in constructing a Likert scale.
3. Briefly explain the concepts of reliability, validity and sensitivity.

Long-Answer Questions

1. Discuss four types of measurements using examples.
2. Define attitude. What are its various components?
3. Explain an itemized rating scale. What are the various issues involved in constructing an itemized rating scale?

5.9 FURTHER READINGS

NOTES

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UNIT 6 QUESTIONNAIRE DESIGN

NOTES

Structure

6.0 INTRODUCTION

In Unit 4, we discussed some of the methods of primary data like observation, focus group discussion and interviews. However, a discussion on data collection would be incomplete if one did not talk about the questionnaire method. This is the most cost effective and widely used method, apart from being extremely user friendly. The questionnaire method is flexible enough to reveal data that is in the respondents own words and language. It can be made extremely scientific by framing questions which enable a very advanced level of quantitative measurement and analysis. The pattern of questioning is always designed, keeping in mind the respondent's comfort and ease of answering. Today, with the wide use of technology it is very easy to use the questionnaire method even without being present physically in front of the respondent.

Even though all of us have filled a questionnaire at some time or the other and know what it must have, designing a well structured and study specific questionnaire requires a structured and logical path so that the effort of collecting information using the questionnaire is meaningful. In this unit you will learn about the various aspects of the questionnaire method in detail. The entire process of questionnaire designing will be discussed at length, with special reference to the different kinds of questionnaires available to the researcher.

6.1 OBJECTIVES

After going through this unit, you will be able to:

- Recognize the relevance on the questionnaire method in research
- Describe the step-wise process involved in the design of a questionnaire

- Define the content of the questions
- Define the flow and sequence in the questioning method
- Recognize the advantages and disadvantages of using the questionnaire

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6.2 THE QUESTIONNAIRE METHOD

The questionnaire is a research technique that consists of a series of questions asked to respondents, in order to obtain statistically useful information about a given topic. It is one of the most cost-effective methods of collecting primary data, which can be used with considerable ease by most individual and business researchers. It has the advantage of flexibility of approach and can be successfully adapted for most research studies. The instrument has been defined differently by various researchers. Some take the traditional view of a written document requiring the subject to record his/her own responses (Kervin,1999). Others have taken a broader perspective to include structured interview also as a questionnaire (Bell, 1999). It is essentially a data-collection instrument that has a predesigned set of questions, following a particular structure (De Vaus, 2002). Since it includes a standard set of questions, it can be successfully used to collect information from a large sample in a reasonably short time period.

However, the use of questionnaire is not always the best method in all research studies. For example, at the exploratory stage, rather than questionnaire, it is advisable to use a more unstructured interview. Secondly, when the number of respondents is small and one has to collect more subjective data, then a questionnaire is not advisable.

Criteria for designning a questionnaire

There are certain criteria that must be kept in mind while designing the questionnaire. The first and foremost requirement is that the spelt-out research objectives must be converted into clear questions which will extract answers from the respondent. This is not as easy as it sounds, for example, if one wants to know how many times your teacher praised you in the week? It is very difficult to give an exact number. The second requirement is, it should be designed to engage the respondent and encourage a meaningful response. For example, a questionnaire measuring stress cannot have a voluminous set of questions which fatigue the subject. The questions, thus, should encourage response and be easy to understand. Lastly, the questions should be self-explanatory and not confusing as then the person will answer the way he understood the question and not in terms of what was asked. This will be discussed in detail later, when we discuss the wording of the questions.

6.2.1 Types of Questionnaire

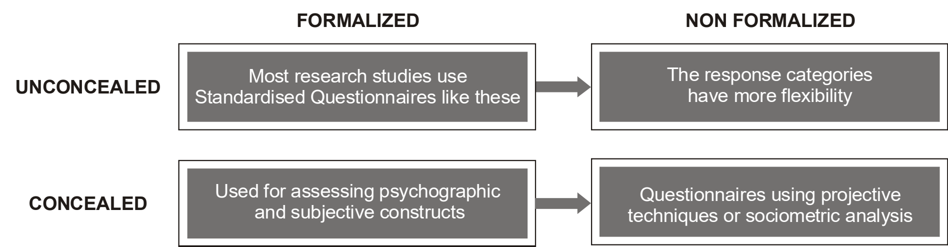
There are many different types of questionnaire available to the researcher. The categorization can be done on the basis of a variety of parameters. The two criteria

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that are most frequently used for designing purposes are the degree of structure and the degree of concealment. Structure refers to the degree to which the response category has been defined. Concealment refers to the degree to which the purpose of the study is explained to the respondent.

Instead of considering them as individual types, most research studies use a mixed format. Thus, they will be discussed here as a two-by-two matrix (Table 6.1).

Table 6.1 *Types of Questionnaire*



Let us discuss the types of questionnaires. Qustionnaires can be categorized on the basis of their structure or method of administration.

Based on the structure, questionnaires can be divided into the following categories:

Formalized and unconcealed questionnaire: This is the one that is the most frequently used by all management researchers. For example, if a new brokerage firm wants to understand the investment behaviour of people, they would structure the questions and answers as follows:

1. Do you carry out any investment(s)?

   Yes ________ No _________

   If yes, continue, else terminate.

2. Out of the following options, where do you invest? (tick all that apply).

   Precious metals _________, real estate _________, stocks _________,

   government instruments _________, mutual funds _________,

   any other _________.

This kind of structured questionnaire is easy to administer, and has both the questions as self-explanatory and the answer categories clearly defined.

Formalized and concealed questionnaire: These questionnaires have a formal method of questioning; however the purpose is not clear to the respondent. The research studies which are trying to find out the latent causes of behaviour and cannot rely on direct questions use these. For example young people cannot be asked direct questions on whether they are likely to indulge in corruption at work. Thus, the respondent has to be given a set of questions that can give an indication of what are his basic values, opinions and beliefs, as these would influence how he would react to issues.

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Non-formalized and unconcealed: Some researchers argue that rather than giving the respondents pre-designed response categories, it is better to give them unstructured questions where they have the freedom of expressing themselves the way they want to. Some examples of these kinds of questions are given below:

1. Why do you think Maggi noodles are liked by young children?

   ____

2. How do you generally decide on where you are going to invest your money?

   ____

3. Give THREE reasons why you believe that the show *Satyamev Jayate* has affected the common Indian person?

   ____

The data obtained here is rich in content, but quantification cannot go beyond frequency and percentages to represent the findings.

Non-formalized and concealed: If the objective of the research study is to uncover socially unacceptable desires and subconscious and unconscious motivations, the investigator makes use of questions of low structure and disguised purpose. However, these require interpretation that is highly skilled. Cost, time and effort are also much higher than others.

Another useful way of categorizing questionnaires is on the method of administration. Thus, the questionnaire that has been prepared would necessitate a face-to-face interaction. In this case, the interviewer reads out each question and makes a note of the respondent's answers. This administration is called a ***schedule***. It might have a mix of the questionnaire type as described in the section above and might have some structured and some unstructured questions. The other kind is the ***self-administered questionnaire***, where the respondent reads all the instructions and questions on his own and records his own statements or responses. Thus, all the questions and instructions need to be explicit and self-explanatory.

The selection of one over the other depends on certain study prerequisites.

Population characteristics: In case the population is illiterate or unable to write the responses, then one must as a rule use the schedule, as the questionnaire cannot be effectively answered by the subject himself.

Population spread: In case the sample to be studied is large and widely spread, then one needs to use the questionnaire. When the resources available for the study are limited, then schedules become expensive to use and the self-administered questionnaire is better.

Study area: In case one is studying a sensitive topic like harassment at work- a self administered questionnaire is suggested. However, in case the study topic needs additional probing then in that case a schedule is better.

There is another categorization that is based upon the mode of administration; this would be discussed in later sections of the unit.

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Check Your Progress

1. State the first and foremost requirement of a questionnaire.
2. Which type of questionnaire is used if the objective of the research is to uncover socially unacceptable desires and subconscious and unconscious motivations?
3. Name the categories of questionnaires on the basis of method of administration.

6.3 PROCESS OF QUESTIONNAIRE DESIGNING

Even though the questionnaire method is most used by researchers, designing a well-structured instrument needs considerable skill. Presented below is a standardized process that a researcher can follow.

Figure 6.1 summarizes the steps involved in questionnaire design.

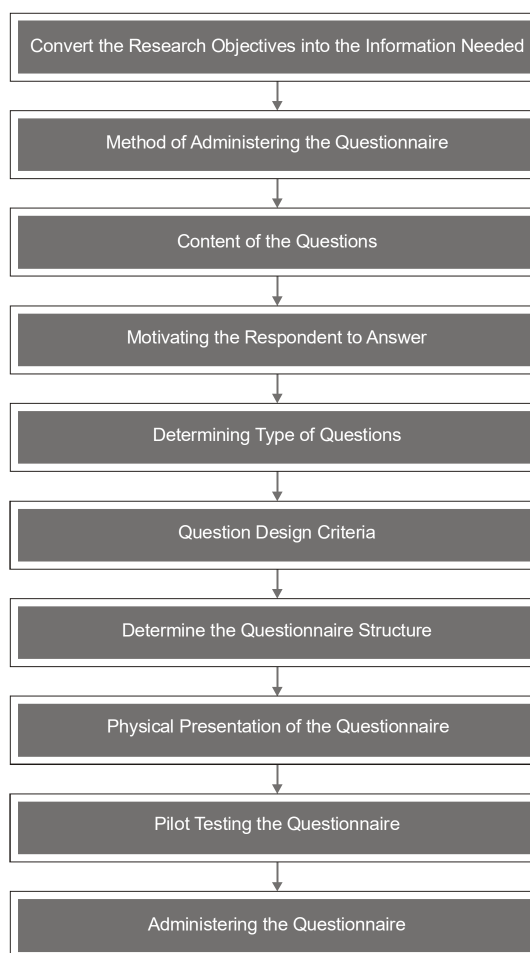


Fig. 6.1 *Questionnaire Design Process*

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1. Convert the research objectives into information areas

This is the first step of the design process. By this time the researcher is clear about the research questions; research objectives; variables to be studied; research information required and the characteristics of the population being studied. Once these tasks are done, one can prepare a tabled framework so that the questions which need to be developed become clear. This step-wise process is explained with an example in Table 6.2.

Table 6.2 *Framework for Identifying Information Needs*

Research Questions	Research Objectives	Variables to be Studied	Information (Primary Required)	Population to be Studied
What is the nature of plastic bag usage amongst people in the NCR (National Capital Region)?	To identify the different uses of plastic bags. To find out the method of disposal of plastic bags. To find out who uses plastic bags. To find out what is the level of consciousness that people have about the environment.	Usage behaviour Demographic details	Uses of plastic bags Disposal of plastic bags	Consumers Retailers

2. Method of administration

Once the researcher has identified his information area; he needs to specify how the information should be collected. The researcher usually has available to him a variety of methods for administering the study. The main methods are personal schedule (discussed earlier in the unit), self-administered questionnaire through mail, fax, e-mail and web-based questionnaire. There are different preconditions for using one method over the other (Table 6.3).

Table 6.3 *Mode of Administration and Design Implications*

	Schedule	Telephone	Mail/Fax	E-mail	Web-Based
Administrative control	high	medium	Low	low	low
Sensitive issues	high	medium	Low	low	low
New concept	high	medium	Low	low	low
Large sample	low	low	High	high	high
Cost/time taken	high	medium	Medium	low	low
Question structure	unstructured	either	structured	structured	structured
Sampling control	high	high	Medium	low	low
Response rate	high	high	Low	medium	low
Interviewer bias	high	high	low	low	low

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3. Content of the questionnaire

The next step is to determine the matter to be included as questions in the measure. The researcher needs to do an objective quality check in order to see what research objective/information need the question would be covering before using any of the framed questions.

How essential is it to ask the question? You must remember that the time of the respondent is precious and it should not be wasted. Unless a question is adding to the data needed for getting an answer to the research problem, it should not be included. For example, if one is studying the usage of plastic bags, then demographic questions on age group, occupation, education and gender might make sense but questions related to marital status, family size and the state to which the respondent belongs are not required as they have no direct relation with the usage or attitude towards plastic bags.

Sometimes, especially in self-administered questionnaires, one may ask some neutral questions at the beginning of the questionnaire to establish an involvement and rapport. For example, for a biofertilizer usage study, the following question was asked:

Farming for you is a:

noble profession
ancestral profession
profession like any other
profession that is not money making
any other

Do we need to ask several questions instead of a single one? After deciding on the significance of the question, one needs to ascertain whether a single question will serve the purpose or should more than one question be asked. For example, in a TV serial study, one may give ten popular serials to be ranked as 1 to 10 in order of preference. Then the second question after the ranking question is:

'Why do you like the serial __________ (the one you ranked No. 1/prefer watching most)?' (Incorrect)

Here, one lady might say, 'Everyone in my family watches it'. While another might say, 'It deals with the problems of living in a typical Indian joint family system' and yet another might say, 'My friend recommended it to me'.

Thus, we need to ask her:

'What do you like about__________?'

'Who all in your household watch the serial?'

and

'How did you first hear about the serial?' (Correct)

4. Motivating the respondent to answer

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The questionnaire should be designed in a manner that it involves the respondent and motivates him/her to give information. There are different situations which might lead to this. Each of these is examined separately here:

Does the person have the required information? It has been found that the person has had no experience with the issue being studied. Look at the following question:

How do you evaluate the negotiation skills module, viz., the communication and presentation skill module? (Incorrect)

In this case it might be that the person has not undergone one or even both the modules, so how can he compare? Thus, certain qualifying or filter questions must be asked. Filter questions enable the researcher to filter out the respondents who are not adequately informed. Thus, the correct question would have been:

Have you been through the following training modules?

- Negotiation skills module Yes/no
- Communication and presentation skills Yes/no

In case the answer to both is yes, please answer the following question, or else move to the next question.

How do you evaluate the negotiation skills module, viz., the communication and presentation skill module? (Correct)

Does the person remember? Many a times, the question addressed might be putting too much stress on an individual's memory. For example, consider the following questions:

How much did you spend on eating out last month? (Incorrect)

Such questions are beyond any normal individual's memory bank. Thus, the questions listed above could have been rephrased as follows:

When you go out to eat, on an average your bill amount is:

Less than ₹100

₹101–250

₹251–500

More than ₹500

How often do you eat out in a week?

1–2 times

3–4 times

5–6 times

Every day (correct)

Can the respondent articulate? Sometimes the respondent might not know how to put the answer in clear words. For example, if you ask a respondent to:

- Describe a river rafting experience.

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Most respondents would not know what phrases to use to give an answer. Thus, in the above case, one can provide answer categories to the person as follows:

Describe the river rafting experience. (Correct)

1	Unexciting		Exciting
2	Bad		Good
3	Boring		Interesting
4	Cheap		Expensive
5	Safe		Dangerous

Sensitive information: There might be instances when the question being asked might be embarrassing to the respondents and thus they would not be comfortable in disclosing the data required.

For example, questions such as the following will not get any answers.

Have you ever used fake receipts to claim your medical allowance? (Incorrect)

Have you ever spit tobacco on the road (to tobacco consumers)? (Incorrect)

However, in case the socially undesirable habit is in the context of a third person, the chances of getting some correct responses are possible. Thus the questions should be rephrased as follows:

Do you associate with people who use fake receipts to claim their medical allowance? (Correct)

Do you think tobacco consumers spit tobacco on the road? (Correct)

5. Determining the type of questions

Available to the researcher are different kinds of question-response options (Figure 6.2)

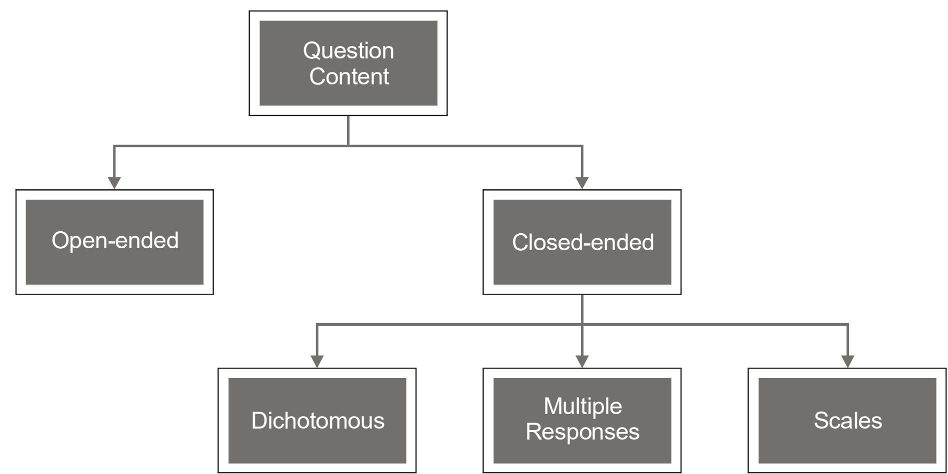


Fig. 6.2 *Types of Question–Response Options*

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Open-ended questions

In open-ended questions, the openness refers to the option of answering in one's own words. They are also referred to as unstructured questions or free-response or free-answer questions. Some illustrations of this type are listed below:

- What is your age?
- Which is your favourite TV serial?
- I like Nescafe because ________________________
- My career goal is to ________________________

Closed-ended questions

In closed-ended questions, both the question and response formats are structured and defined.There are three kinds of formats as we observed earlier—dichotomous questions, multiple–choice questions and those that have a scaled response.

i. Dichotomous questions: These are restrictive alternatives and provide the respondents only with two answers. These could be 'yes' or 'no', like or dislike, similar or different, married or unmarried, etc.

Are you diabetic?	Yes/No
Have you read the new book by Dan Brown?	Yes/no
What kind of petrol do you use in your car?	Normal/Premium

Dichotomous questions are the easiest type of questions to code and analyse. They are based on the nominal level of measurement and are categorical or binary in nature.

ii. Multiple-choice questions: Unlike dichotomous questions, the person is given a number of response alternatives here. He might be asked to choose the one that is most applicable. For example, this question was given to a retailer who is currently not selling organic food products:

Will you consider selling organic food products in your store?

- Definitely not in the next one year
- Probably not in the next one year
- Undecided
- Probably in the next one year
- Definitely in the next one year

Sometimes, multiple-choice questions do not have verbal but rather numerical options for the respondent to choose from, for example:

How much do you spend on grocery products (average in one month)?

Less than ₹2500/-

Between ₹2500–5000/-

More than ₹5000/-

Most multiple-choice questions are based upon ordinal or interval level of measurement. There could also be instances when multiple options are given to

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the respondent and he can select all those that apply in the case. These kinds of multiple-choice questions are called *checklists.* For example, in the organic food study, the retailer who does not stock organic products was given multiple reasons as follows:

You do not currently sell organic food products because (Could be ≥ 1)

- You do not know about organic food products.
- You are not interested.
- Organic products do not have attractive packaging.
- Organic food products are not supplied regularly.
- Any other ___________________________

iii. Scales: Scales refer to the attitudinal scales that were discussed in detail in Unit 5. Since these questions have been discussed in detail in the earlier unit, we will only illustrate this with an example. The following is a question which has two sub-questions designed on the Likert scale. These require simple agreement and disagreement on the part of the respondent. This scale is based on the interval level of measurement.

Given below are statements related to your organization. Please indicate your agreement/disagreement with each:

(1-Strongly Disagree → → → → 5 Strongly Agree)	1	2	3	4	5
1. The people in my company know their roles very clearly.					
2. I want to complete my current task by hook or by crook.					

6. Criteria for question designing

Step six of the questionnaire involves translating the questions identified into meaningful questions. There are certain designing criteria that a researcher should keep in mind when writing the research questions.

Clearly specify the issue: By reading the question, the person should be able to clearly understand the information need.

Which newspaper do you read? (Incorrect)

This might seem to be a well-defined and structured question. However, the 'you' could be the person filling the questionnaire or the family. He could be reading different newspapers. He might be reading different papers at home and may be the college library. A better way to word the question would be:

Which newspaper or newspapers did you personally read at home during the last month? In case of more than one newspaper, please list all that you read. (Correct)

Use simple terminology: The researcher must take care to ask questions in a language that is understood by the population under study. Technical words or difficult words that are not used in everyday communication must be avoided.

Do you think thermal wear provides immunity? (Incorrect)

Do you think that thermal wear provides you protection from the cold? (Correct)

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Avoid ambiguity in questioning: The words used in the questionnaire should mean the same thing to all those answering the questionnaire. A lot of words are subjective and relative in meaning. Consider the following question:

How often do you visit Pizza Hut?

Never

Occasionally

Sometimes

Often

Regularly (Incorrect)

These are ambiguous measures, as *occasionally* in the above question, might be three to four times in a week for one person it, while for another it could be three times in a month. A much better wording for this question would be the following:

In a typical month, how often do you visit Pizza Hut?

Less than once

1 or 2 times

3 or 4 times

More than 4 times (Correct)

Avoid leading questions: Any question that provides a clue to the respondents in terms of the direction in which one wants them to answer is called a leading or biasing question. For example, 'Do you think that working mothers should buy ready-to-eat food when that might contain some chemical preservatives?

Yes

No

Don't know (Incorrect)

The question would mostly generate a negative answer, as no working mother would like to buy something that is convenient but might be harmful. Thus, it is advisable to construct a neutral question as follows:

Do you think that working mothers should buy ready-to-eat food?

Yes

No

Don't know (Correct)

Avoid loaded questions: Questions that address sensitive issues are termed as loaded questions and the response to these questions might not always be honest, as the person might not wish to admit the answer. For example, questions such as follows will rarely get an affirmative answer:

Will you take dowry when you get married? (Incorrect)

Sensitive questions like this can be rephrased in a variety of ways. For example, the question could be constructed in the context of a third person as follows:

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Do you think most Indian men would take dowry when they get married? (Correct)

Avoid double-barrelled questions: Questions that have two separate options separated by an 'or' or 'and' like the following:

Do you think Nokia and Samsung have a wide variety of touch phones? Yes/No (Incorrect)

The problem is that the respondent might believe that Nokia has better phones or Samsung has better phones or both. These questions are referred to as double-barrelled and the researcher should always split them into two separate questions. For example,

A wide variety of touch phones is available for:

Nokia

Samsung

Both (Correct)

7. Determine the questionnaire structure

The questions now have to be put together in a proper sequence.

Instructions: The questionnaires always, even the schedules, begin with standardized instructions. These begin by greeting the respondent and then introducing the researcher and then the purpose of questionnaire administration. For example, in the study on organic food products, the following instructions were given at the beginning of the questionnaire:

'Hi. We __________ are carrying out a market research on the purchase behaviour of grocery products/organic food. We are conducting a survey of consumers, retailers and experts in the NCR for the same.

As you are involved in the purchase and/or consumption of food products, we seek your cooperation for providing the following relevant information for our research. Thank you very much.'

Opening questions: After instructions come the opening questions, which lead the reader into the study topic. For example, a questionnaire on understanding the consumer's buying behavior in malls can ask an opening question that is generic in nature, such as:

What is your opinion about shopping at a mall?

Study questions: After the opening questions, the bulk of the instrument needs to be devoted to the main questions that are related to the specific information needs

of the study. Here also, the general rule is that the simpler questions, which do not require a lot of thinking or response time should be asked first as they build the tempo for answering the more difficult/sensitive questions later on. This method of going in a sequential manner from the general to the specific is called the funnel approach.

Classification information: This is the information that is related to the basic socio-economic and demographic traits of the person. These might include name (kept optional in some cases), address, e-mail address and telephone number.

Acknowledgement: The questionnaire ends by acknowledging the inputs of the respondent and thanking him for his cooperation and valuable contribution.

8. Physical characteristics of the questionnaire

The researcher must pay special attention to the look of the questionnaire. The first thing is the quality of the paper on which the questionnaire is printed which should be of good quality. The font style and spacing used in the entire document should be uniform. One must ensure that every question and its response options are printed on the same page. Surveys for different groups could be on different coloured paper. For example, if Delhi is being studied as five zones, then the questionnaire used in each zone could be printed on a differently coloured paper. Each question and section must be numbered properly. In case there is any response instruction for an individual question, it must be before the question. In case the questionnaire is going to be administered by the investigator and if there are any probing question then they should be clearly written as instructions for the investigator.

9. Pilot testing of the questionnaire

Pilot testing refers to testing and administering the designed instrument on a small group of people from the population under study. This is to essentially cover any errors that might have still remained even after the earlier eight steps. For example the question wording may not be clear, the sequence of questions may not be correct or the question is not needed as it does not solve any purpose. Thus these aspects need to be corrected.Every aspect of the questionnaire has to be tested and one must record all the experiences of the conduction, including the time taken to administer it. Sometimes, the researcher might also get the questionnaire whetted by academic or industry experts for their inputs. As far as possible, the pilot should be a small scale replica of the actual survey that would be subsequently conducted.

10. Administering the questionnaire

Once all the nine steps have been completed, the final instrument is ready for conduction and the questionnaire needs to be administered according to the sampling plan.

6.4 ADVANTAGES AND DISADVANTAGES OF THE QUESTIONNAIRE METHOD

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The questionnaire has many advantages over the other data collection methods discussed earlier.

- Probably the greatest benefit of the method is its adaptability. There is, actually speaking, no domain or branch for which a questionnaire cannot be designed. It can be shaped in a manner that can be easily understood by the population under study. The language, the content and the manner of questioning can be modified suitably. The instrument is particularly suitable for studies that are trying to establish the reasons for certain occurrences or behaviour.
- The second advantage is that it assures anonymity if it is self-administered by the respondent, as there is no pressure or embarrassment in revealing sensitive data. A lot of questionnaires do not even require the person to fill in his/her name. Administering the questionnaire is much faster and less expensive as compared to other primary and a few secondary sources as well. There is considerable ease of quantitative coding and analysis of the obtained information as most response categories are closed-ended and based on the measurement levels as discussed in Unit 5. The chance of researcher bias is very little here.
- Lastly, there is no pressure of immediate response, thus the subject can fill in the questionnaire whenever he or she wants.
- The questionnaire is the most economical method as it can be administered simultaneously to a number of respondents. Thus a large amount of data can be collected within a short time through a questionnaire.

However, the method does not come without any disadvantages.

- The major disadvantage is that the inexpensive standardized instrument has limited applicability, that is, it can be used only with those who can read and write.
- The questionnaire is an impersonal method and sometimes for a sensitive issue it may not reveal the actual reasons or answers to the questionsthat you asked.The return ratio, i.e., the number of people who return the duly filled in questionnaires are sometimes not even 50 per cent of the number of forms distributed.
- Skewed sample response could be another problem. This can occur in two cases; one, if the investigator distributes the same to his friends and acquaintances and second, because of the self-selection of the subjects. This means that the ones who fill in the questionnaire and return it might not be the representatives of the population at large. In case the person is not clear about a question, clarification with the researcher might not be possible.

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Check Your Progress

4. What are some of the other names for open-ended questions?
5. Name the method in which sampling control is the highest.
6. 'Do you sing and dance?' is an example of which type of question?
7. State the greatest benefit of the questionnaire method.

6.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The first and foremost requirement of a questionnaire is that the spelt-out research objectives must be converted into clear questions which will extract answers from the respondent.
2. The non-formalized and concealed questionnaire is used if the objective of the research is to uncover socially unacceptable desires and subconscious and unconscious motivations.
3. The categories of questionnaires on the basis of method of administration are schedule and self-administered questionnaire.
4. The other names for open-ended questions are unstructured questions or free-response or free-answer questions.
5. Schedule is the method in which sampling control is the highest.
6. 'Do you sing and dance?' is an example of a double-barreled question.
7. The greatest benefit of the questionnaire method is its adaptability.

6.6 SUMMARY

- The questionnaire is a research technique that consists of a series of questions asked to respondents, in order to obtain statistically useful information about a given topic.
- It is one of the most cost-effective methods of collecting primary data, which has the advantage of flexibility of approach and can be successfully adapted for most research studies.
- There are many different types of questionnaire available to the researcher.
- Based on the structure, questioannaires can be categorized into unconcealed and formalized, concealed and formalized, unconcealed and non-formalized and concealed and non-formalized.
- Based on the method of administration, the questionnaire could be in the form of a schedule or self-administered questionnaire.

6.7 KEY WORDS

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- **Questionnaire:** A research tool that consists of a series of questions asked to respondents, in order to obtain statistically useful information about a given topic.
- **Schedule:** Questionnaire with a face-to-face interaction in which the interviewer reads out each question and makes a note of the respondent's answers.
- **Dichotomous questions:** Questions with restrictive alternatives that provide the respondents only with two answers.
- **Double-barrelled questions:** Questions that have two separate options separated by an 'or' or 'and'.

6.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is a questionnaire? What are the criteria of a sound questionnaire?
2. Write short notes on the following:
   (a) Formalized and concealed questionnaire
   (b) Non-formalized and unconcealed questionnaire
   (c) Non-formalized and concealed questionnaire
3. What are the different criteria for designing questions in a questionnaire?

Long-Answer Questions

1. What are the steps involved in the questionnaire design? Explain in detail the questionnaire design process.
2. What are the advantages and disadvantages of the questionnaire method? Illustrate with suitable examples.

6.9 FURTHER READINGS

Bell, J. 1999. *Doing Your Research Project.* 3rd edn. Buckingham: Open University Press.

De Vaus, D A. 2002. *Surveys in Social Research.* 5th edn. London: Routledge.

Kervin, J B. 1999. *Methods for Business Research,* 2nd edn. Reading, MA: Addison-Wesley.

UNIT 7 SAMPLING

NOTES

Structure

7.0 INTRODUCTION

In Unit 5, we discussed the concept of attitude measurement and scaling. In this unit, we will discuss an important aspect of research – sampling. Let us understand what is sampling and what role it plays in research.

As we have discussed earlier, research objectives are generally translated into research questions that enable the researchers to identify the information needs. Once the information needs are specified, the sources of collecting the information are sought. Some of the information may be collected through secondary sources (published material), whereas the rest may be obtained through primary sources. The primary methods of collecting information could be the observation method, personal interview with questionnaire (which we learnt in previous unit), telephone surveys and mail surveys. Surveys are, therefore, useful in information collection, and their analysis plays a vital role in finding answers to research questions. Survey respondents should be selected using the appropriate procedures; otherwise the researchers may not be able to get the right information to solve the problem under investigation. This is done through sampling.

In this unit, we will discuss in detail the concept of sampling, including sampling and non-sampling error, probability and non-probability sampling designs, as well as determination of sample size.

7.1 OBJECTIVES

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After going through this unit, you will be able to:

- Explain the basic concepts of sampling.
- Distinguish between sample and census.
- Differentiate between a sampling and non-sampling error.
- Describe the meaning of sampling design.
- Explain different types of probability sampling designs.
- Describe various types of non-probability sampling designs.
- Estimate the sample size required while estimating the population mean and proportion.

7.2 SAMPLING CONCEPTS

The process of selecting the right individuals, objects or events for a study is known as sampling. Sampling involves the study of a small number of individuals, objects chosen from a larger group. Before we get into the details of various issues pertaining to sampling, it would be appropriate to discuss some of the sampling concepts.

Population: Population refers to any group of people or objects that form the subject of study in a particular survey and are similar in one or more ways. For example, the number of full-time MBA students in a business school could form one population. If there are 200 such students, the population size would be 200. We may be interested in understanding their perceptions about business education. If, in an organization there are 1,000 engineers, out of which 350 are mechanical engineers and we are interested in examining the proportion of mechanical engineers who intend to leave the organization within six months, all the 350 mechanical engineers would form the population of interest. If the interest is in studying how the patients in a hospital are looked after, then all the patients of the hospital would fall under the category of population.

Element: An element comprises a single member of the population. Out of the 350 mechanical engineers mentioned above, each mechanical engineer would form an element of the population.

Sampling frame: Sampling frame comprises all the elements of a population with proper identification that is available to us for selection at any stage of sampling. For example, the list of registered voters in a constituency could form a sampling frame; the telephone directory; the number of students registered with a university; the attendance sheet of a particular class and the payroll of an organization are examples of sampling frames. When the population size is very large, it becomes virtually impossible to form a sampling frame. We know that the number of

consumers of soft drinks is very large and, therefore, it becomes very difficult to form the sampling frame for the same.

Sample: It is a subset of the population. It comprises only some elements of the population. If out of the 350 mechanical engineers employed in an organization, 30 are surveyed regarding their intention to leave the organization in the next six months, these 30 members would constitute the sample.

Sampling unit: A sampling unit is a single member of the sample. If a sample of 50 students is taken from a population of 200 MBA students in a business school, then each of the 50 students is a sampling unit.

Sampling: It is a process of selecting an adequate number of elements from the population so that the study of the sample will not only help in understanding the characteristics of the population but also enables us to generalize the results. We will see later that there are two types of sampling designs—probability sampling design and non-probability sampling design.

Census (or complete enumeration): An examination of each and every element of the population is called census or complete enumeration. Census is an alternative to sampling. We will discuss the inherent advantages of sampling over a complete enumeration later.

7.2.1 Sample vs Census

In a research study, we are generally interested in studying the characteristics of a population. Suppose there are 2 lakh households in a town, and we are interested in estimating the proportion of households that spend their summer vacations in a hill station. This information can be obtained by asking every household in that town. If all the households in a population are asked to provide information, such a survey is called a census. There is an alternative way of obtaining the same information, by choosing a subset of all the two lakh households and asking them for the same information. This subset is called a sample. Based upon the information obtained from the sample, a generalization about the population characteristic could be made. However, that sample has to be representative of the population. For a sample to be representative of the population, the distribution of sampling units in the sample has to be in the same proportion as the elements in the population. For example, if in a town there are 50, 35 and 15 per cent households in lower, middle and upper income groups, then a sample taken from this population should have the same proportions in for it to be representative. There are several advantages of sample over census.

- Sample saves time and cost. Many times a decision-maker may not have too much of time to wait till all the information is available. Therefore, a sample could come to his rescue.
- There are situations where a sample is the only option. When we want to estimate the average life of fluorescent bulbs, what is done is that they are burnt out completely. If we go for a complete enumeration there would not

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be anything left for use. Another example could be testing the quality of a photographic film.

- The study of a sample instead of complete enumeration may, at times, produce more reliable results. This is because by studying a sample, fatigue is reduced and fewer errors occur while collecting the data, especially when a large number of elements are involved.

A census is appropriate when the population size is small, e.g., the number of public sector banks in the country. Suppose the researcher is interested in collecting information from the top management of a bank regarding their views on the monetary policy announced by the Reserve Bank of India (RBI), in this case, a complete enumeration may be possible as the population size is not very large.

7.2.2 Sampling vs Non-Sampling Error

There are two types of error that may occur while we are trying to estimate the population parameters from the sample. These are called sampling and non-sampling errors.

Sampling error: This error arises when a sample is not representative of the population. It is the difference between sample mean and population mean. The sampling error reduces with the increase in sample size as an increased sample may result in increasing the representativeness of the sample.

Non-sampling error: This error arises not because a sample is not a representative of the population but because of other reasons. Some of these reasons are listed below:

- The respondents when asked for information on a particular variable may not give the correct answers. If a person aged 48 is asked a question about his age, he may indicate the age to be 36, which may result in an error and in estimating the true value of the variable of interest.
- The error can arise while transferring the data from the questionnaire to the spreadsheet on the computer.
- There can be errors at the time of coding, tabulation and computation.
- If the population of the study is not properly defined, it could lead to errors.
- The chosen respondent may not be available to answer the questions or may refuse to be part of the study.

Check Your Progress

1. What is the subset of a population called?
2. Define a sampling frame.

7.3 SAMPLING DESIGN

NOTES

Sampling design refers to the process of selecting samples from a population. There are two types of sampling designs—probability sampling design and non-probability sampling design. Probability sampling designs are used in conclusive research. In a probability sampling design, each and every element of the population has a known chance of being selected in the sample. The known chance does not mean equal chance. Simple random sampling is a special case of probability sampling design where every element of the population has both known and equal chance of being selected in the sample.

In case of non-probability sampling design, the elements of the population do not have any known chance of being selected in the sample. These sampling designs are used in exploratory research.

7.3.1 Probability Sampling Design

Under this, the following sampling designs would be covered—simple random sampling with replacement (SRSWR), simple random sampling without replacement (SRSWOR), systematic sampling and stratified random sampling.

Simple random sampling with replacement (SRSWR)

Under this scheme, a list of all the elements of the population from where the samples are to be drawn is prepared. If there are 1,000 elements in the population, we write the identification number or the name of all the 1,000 elements on 1,000 different slips. These are put in a box and shuffled properly. If there are 20 elements to be selected from the population, the simple random sampling procedure involves selecting a slip from the box and reading of the identification number. Once this is done, the chosen slip is put back to the box and again a slip is picked up and the identification number is read from that slip. This process continues till a sample of 20 is selected. Please note that the first element is chosen with a probability of 1/1,000. The second one is also selected with the same probability and so are all the subsequent elements of the population.

Simple random sampling without replacement (SRSWOR)

In case of simple random sample without replacement, the procedure is identical to what was explained in the case of simple random sampling with replacement. The only difference here is that the chosen slip is not placed back in the box. This way, the first unit would be selected with the probability of 1/1,000, second unit with the probability of 1/999, the third will be selected with a probability of 1/998 and so on, till we select the required number of elements (in this case, 20) in our sample.

The simple random sampling (with or without replacement) is not used in consumer research. This is because in a consumer research the population size is usually very large, which creates problems in the preparation of a sampling frame. For example, number of consumers of soft drinks, pizza, shampoo, soap, chocolate,

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etc, is very large. However, these (SRSWR and SRSWOR) designs could be useful when the population size is very small, for example, the number of steel/aluminum-producing companies in India and the number of banks in India. Since the population size is quite small, the preparation of a sampling frame does not create any problem.

Another problem with these (SRSWR and SRSWOR) designs is that we may not get a representative sample using such a scheme. Consider an example of a locality having 10,000 households, out of which 5,000 belong to low-income group, 3,500 belong to middle income group and the remaining 1,500 belong to high-income group. Suppose it is decided to take a sample of 100 households using the simple random sampling. The selected sample may not contain even a single household belonging to the high- and middle-income group and only the low-income households may get selected, thus, resulting in a non-representative sample.

Systematic sampling

Systematic sampling takes care of the limitation of the simple random sampling that the sample may not be a representative one. In this design, the entire population is arranged in a particular order. The order could be the calendar dates or the elements of a population arranged in an ascending or a descending order of the magnitude which may be assumed as random. List of subjects arranged in the alphabetical order could also be used and they are usually assumed to be random in order. Once this is done, the steps followed in the systematic sampling design are as follows:

- First of all, a sampling interval given by $K = N/n$ is calculated,

  where N = the size of the population and n = the size of the sample.

  It is seen that the sampling interval K should be an integer. If it is not, it is rounded off to make it an integer.
- A random number is selected from 1 to K. Let us call it C.
- The first element to be selected from the ordered population would be C, the next element would be $C + K$ and the subsequent one would be $C + 2K$ and so on till a sample of size n is selected.

This way we can get representation from all the classes in the population and overcome the limitations of the simple random sampling. To take an example, assume that there are 1,000 grocery shops in a small town. These shops could be arranged in an ascending order of their sales, with the first shop having the smallest sales and the last shop having the highest sales. If it is decided to take a sample of 50 shops, then our sampling interval K will be equal to 1000 ÷ 50 = 20. Now we select a random number from 1 to 20. Suppose the chosen number is 10. This means that the shop number 10 will be selected first and then shop number 10 + 20 = 30 and the next one would be 10 + (2 × 20) = 50 and so on till all the 50 shops are selected. This way we can get a representative sample in the sense that it will contain small, medium and large shops.

It may be noted that in a systematic sampling the first unit of the sample is selected at random (probability sampling design) and having chosen this, we have no control over the subsequent units of sample (non-probability sampling). Because of this, this design at times is called mixed sampling.

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The main advantage of systematic sampling design is its simplicity. When sampling from a list of population arranged in a particular order, one can easily choose a random start as described earlier. After having chosen a random start, every K_{th} item can be selected instead of going for a simple random selection. This design is statistically more efficient than a simple random sampling, provided the condition of ordering of the population is satisfied.

The use of systematic sampling is quite common as it is easy and cheap to select a systematic sample. In systematic sampling one does not have to jump back and forth all over the sampling frame wherever random number leads and neither does one have to check for duplication of elements as compared to simple random sampling. Another advantage of a systematic sampling over simple random sampling is that one does not require a complete sampling frame to draw a systematic sample. The investigator may be instructed to interview every 10th customer entering a mall without a list of all customers.

Stratified random sampling

Under this sampling design, the entire population (universe) is divided into strata (groups), which are mutually exclusive and collectively exhaustive. By mutually exclusive, it is meant that if an element belongs to one stratum, it cannot belong to any other stratum. Strata are collectively exhaustive if all the elements of various strata put together completely cover all the elements of the population. The elements are selected using a simple random sampling independently from each group.

There are two reasons for using a stratified random sampling rather than simple random sampling. One is that the researchers are often interested in obtaining data about the component parts of a universe. For example, the researcher may be interested in knowing the average monthly sales of cell phones in 'large', 'medium' and 'small' stores. In such a case, separate sampling from within each stratum would be called for. The second reason for using a stratified random sampling is that it is more efficient as compared to a simple random sampling. This is because dividing the population into various strata increases the representativness of the sampling as the elements of each stratum are homogeneous to each other.

There are certain issues that may be of interest while setting up a stratified random sample. These are:

- *What criteria should be used for stratifying the universe (population)?*

  The criteria for stratification should be related to the objectives of the study. The entire population should be stratified in such a way that the elements are homogeneous within the strata, whereas there should be

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heterogeneity between strata. As an example, if the interest is to estimate the expenditure of households on entertainment, the appropriate criteria for stratification would be the household income. This is because the expenditure on entertainment and household income are highly correlated.

Generally, stratification is done on the basis of demographic variables like age, income, education and gender. Customers are usually stratified on the basis of life stages and income levels to study their buying patterns. Companies may be stratified according to size, industry, profits for analysing the stock market reactions.

- *How many strata should be constructed?*

  Going by common sense, as many strata as possible should be used so that the elements of each stratum will be as homogeneous as possible. However, it may not be practical to increase the number of strata and, therefore, the number may have to be limited. Too many strata may complicate the survey and make preparation and tabulation difficult. Costs of adding more strata may be more than the benefit obtained. Further, the researcher may end up with the practical difficulty of preparing a separate sampling frame as the simple random samples are to be drawn from each stratum.

- *What should be appropriate number of samples size to be taken in each stratum?*

  This question pertains to the number of observations to be taken out from each stratum. At the outset, one needs to determine the total sample size for the universe and then allocate it between each stratum. This may be explained as follows:

  Let there be a population of size N. Let this population be divided into three strata based on a certain criterion. Let N_1, N_2 and N_3 denote the size of strata 1, 2 and 3 respectively, such that $N = N_1 + N_2 + N_3$. These strata are mutually exclusive and collectively exhaustive. Each of these three strata could be treated as three populations. Now, if a total sample of size n is to be taken from the population, the question arises that how much of the sample should be taken from strata 1, 2 and 3 respectively, so that the sum total of sample sizes from each strata adds up to n.

  Let the size of the sample from first, second and third strata be n_1, n_2, and n_3 respectively such that $n = n_1 + n_2 + n_3$. Then, there are two schemes that may be used to determine the values of n_i, $(i = 1, 2, 3)$ from each strata. These are proportionate and disproportionate allocation schemes.

Proportionate allocation scheme: In this scheme, the size of the sample in each stratum is proportional to the size of the population of the strata. For example, if a bank wants to conduct a survey to understand the problems that its customers are

facing, it may be appropriate to divide them into three strata based upon the size of their deposits with the bank. If we have 10,000 customers of a bank in such a way that 1,500 of them are big account holders (having deposits of more than ₹10 lakh), 3,500 of them are medium-sized account holders (having deposits of more than ₹2 lakh but less than ₹10 lakh), the remaining 5,000 are small account holders (having deposits of less than 2 lakh). Suppose the total budget for sampling is fixed at ₹20,000 and the cost of sampling a unit (customer) is ₹20. If a sample of 100 is to be chosen from all the three strata, the size of the sample from strata 1 would be:

$$n_1 = n \times \frac{N_1}{N} = 100 \times \frac{1500}{10000} = 15$$

The size of sample from strata 2 would be:

$$n_2 = n \times \frac{N_2}{N} = 100 \times \frac{3500}{10000} = 35$$

The size of sample from strata 3 would be:

$$n_3 = n \times \frac{N_3}{N} = 100 \times \frac{5000}{10000} = 50$$

This way the size of the sample chosen from each stratum is proportional to the size of the stratum. Once we have determined the sample size from each stratum, one may use the simple random sampling or the systematic sampling or any other sampling design to take out samples from each of the strata.

Disproportionate allocation: As per the proportionate allocation explained above, the sizes of the samples from strata 1, 2 and 3 are 15, 35 and 50 respectively. As it is known that the cost of sampling of a unit is ₹20 irrespective of the strata from where the sample is drawn, the bank would naturally be more interested in drawing a large sample from stratum 1, which has the big customers, as it gets most of its business from strata 1. In other words, the bank may follow a disproportionate allocation of sample as the importance of each stratum is not the same from the point of view of the bank. The bank may like to take a sample of 45 from strata 1 and 40 and 15 from strata 2 and 3 respectively. Also, a large sample may be desired from the strata having more variability.

7.3.2 Non-probability Sampling Designs

Under the non-probability sampling, the following designs would be considered—convenience sampling, purposive (judgemental) sampling and snowball sampling.

Convenience sampling

Convenience sampling is used to obtain information quickly and inexpensively. The only criterion for selecting sampling units in this scheme is the convenience of the researcher or the investigator. Mostly, the convenience samples used are neighbours, friends, family members, colleagues and 'passers-by'. This sampling

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design is often used in the pre-test phase of a research study such as the pre-testing of a questionnaire. Some of the examples of convenience sampling are:

- People interviewed in a shopping centre for their political opinion for a TV programme.
- Monitoring the price level in a grocery shop with the objective of inferring the trends in inflation in the economy.
- Requesting people to volunteer to test products.
- Using students or employees of an organization for conducting an experiment.

In all the above situations, the sampling unit may either be self-selected or selected because of ease of availability. No effort is made to choose a representative sample. Therefore, in this design the difference between the population value (parameters) of interest and the sample value (statistic) is unknown both in terms of the magnitude and direction. Therefore, it is not possible to make an estimate of the sampling error and researchers would not be able to make a conclusive statement about the results from such a sample. It is because of this, convenience sampling should not be used in conclusive research (descriptive and causal research).

Convenience sampling is commonly used in exploratory research. This is because the purpose of an exploratory research is to gain an insight into the problem and generate a set of hypotheses which could be tested with the help of a conclusive research. When very little is known about a subject, a small-scale convenience sampling can be of use in the exploratory work to help understand the range of variability of responses in a subject area.

Judgemental sampling

Under judgemental sampling, experts in a particular field choose what they believe to be the best sample for the study in question. The judgement sampling calls for special efforts to locate and gain access to the individuals who have the required information. Here, the judgement of an expert is used to identify a representative sample. For example, the shoppers at a shopping centre may serve to represent the residents of a city or some of the cities may be selected to represent a country. Judgemental sampling design is used when the required information is possessed by a limited number/category of people. This approach may not empirically produce satisfactory results and, may, therefore, curtail generalizability of the findings due to the fact that we are using a sample of experts (respondents) that are usually conveniently available to us. Further, there is no objective way to evaluate the precision of the results. A company wanting to launch a new product may use judgemental sampling for selecting 'experts' who have prior knowledge or experience of similar products. A focus group of such experts may be conducted to get valuable insights. Opinion leaders who are knowledgeable are included in

the organizational context. Enlightened opinions (views and knowledge) constitute a rich data source. A very special effort is needed to locate and have access to individuals who possess the required information.

The most common application of judgemental sampling is in business-to-business (B to B) marketing. Here, a very small sample of lead users, key accounts or technologically sophisticated firms or individuals is regularly used to test new product concepts, producing programmes, etc.

Quota Sampling

In quota sampling, the sample includes a minimum number from each specified subgroup in the population. The sample is selected on the basis of certain demographic characteristics such as age, gender, occupation, education, income, etc. The investigator is asked to choose a sample that conforms to these parameters. Field workers are assigned quotas of the sample to be selected satisfying these characteristics. We will discuss quoto sampling later on.

Snowball sampling

Snowball sampling is generally used when it is difficult to identify the members of the desired population, e.g., deep-sea divers, families with triplets, people using walking sticks, doctors specializing in a particular ailment, etc. Under this design each respondent, after being interviewed, is asked to identify one or more in the field. This could result in a very useful sample. The main problem is in making the initial contact. Once this is done, these cases identify more members of the population, who then identify further members and so on. It may be difficult to get a representative sample. One plausible reason for this could be that the initial respondents may identify other potential respondents who are similar to themselves. The next problem is to identify new cases.

Snow-ball sampling is very suitable in studying social groups, informal groups in a formal organization and diffusion of information among professionals of various kinds.

Advantage

The main advantage of snow-ball sampling is that it is useful for smaller populations for which no frames are readily available.

Disadvantages

The following are the disadvantages of this method:

- It does not allow the use of probability statistical methods.
- It is difficult to apply when the population is large.
- It does not ensure the inclusions of all the elements in the list.

Other types of sampling

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- **Voluntary sample:** A voluntary sample is made up of people who self-select into the survey. Often, these folks have a strong interest in the main topic of the survey. Suppose, for example, that a news show asks viewers to participate in an on-line poll. This would be a volunteer sample. The sample is chosen by the viewers, not by the survey administrator.
- **Multistage sampling:** With multistage sampling, we select a sample by using combinations of different sampling methods. For example, in Stage 1, we might use cluster sampling to choose clusters from a population. Then, in Stage 2, we might use simple random sampling to select a subset of elements from each chosen cluster for the final sample.
- **Replicated or interpenetrating sampling:** Replicated sampling involves selection of a certain number of sub-samples rather than one full sample from a population. All the sub-samples should be drawn using the same sampling technique and each is a self-contained and adequate sample of the population. Replicated sampling technique can be used with any basic sampling technique: simple or stratified, single or multistage or single or multi-phase sampling. It provides a simple means of calculating the sampling error. It is practical. The replicated samples can throw light on variables and non-sampling errors. The only disadvantage is that it limits the amount of stratification that can be employed.
- **Area sampling:** Area sampling is also a form of cluster sampling. In a large field survey cluster consisting of specific geographical areas like districts, tallukas, blocks, villages, in a city are randomly drawn. When geographical areas are selected as sampling units, their sampling is known as area sampling.
- **Double sampling and multi-phase sampling:** Double sampling refers to the subsection of the final sample form a preselected larger sample that provided information for improving the final selection. When the procedure is extended to more than two phases of selection, it is then called multi-phase sampling. This is also known as sequential sampling, as sub-sampling is done form a main sample in phases. Double sampling or multi-phase sampling is a compromise solution for a dilemma posed by undesirable extremes. The statistics based on the sample of 'n' can be improved by using ancillary information from a wide base, but this is too costly to obtain from the entire population of N elements. Instead, information is obtained from a larger preliminary sample which includes the final sample n.

Quota Sampling

As discussed, quota sampling is a form of convenient sampling which involves selection of quota groups of accessible sampling units by traits such as sex, age,

social class, etc. It is a method of stratified sampling in which the selection within strata is known as random. It is this known random element that constitutes its greatest weakness.

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This sampling method is used in studies like marketing service, opinion polls and readership service which do not aim at making decisions, but try to get some crude results quickly.

Advantages

The following are the advantages of quota sampling:

- It is less costly.
- It takes less time.
- There is no need for a list of the population.
- The field work can easily be organized.

Disadvantages

The following are the disadvantages of quota sampling:

- It is impossible to estimate sampling error.
- Strict control if field work is difficult.
- It is subject to a higher degree of classification.

Check Your Progress

3. Name the sampling in where every element of the population has both known and equal change of being selected in the sample.
4. Which sampling design is often used in the pre-test phase of a research study as the pre-testing of a questionnaire?
5. What is snowball sampling?

7.4 DETERMINATION OF SAMPLE SIZE

The size of a sample depends upon the basic characteristics of the population, the type of information required from the survey and the cost involved. Therefore, a sample may vary in size for several reasons. The size of the population does not influence the size of the sample as will be shown later on.

There are various methods of determining the sample size in practice:

- Researchers may arbitrarily decide the size of sample without giving any explicit consideration to the accuracy of the sample results or the cost of sampling. This arbitrary approach should be avoided.

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- For some of the projects, the total budget for the field survey (usually mentioned) in a project proposal is allocated. If the cost of sampling per sample unit is known, one can easily obtain the sample size by dividing the total budget allocation by the cost of sampling per unit. This method concentrates only on the cost aspect of sampling, rather than the value of information obtained from such a sample.
- There are other researchers who decide on the sample size based on what was done by the other researchers in similar studies. Again, this approach cannot be a substitute for the formal scientific approach.
- The most commonly used approach for determining the size of sample is the confidence interval approach covered under inferential statistics. Below will be discussed this approach while determining the size of a sample for estimating population mean and population proportion. In a confidence interval approach, the following points are taken into account for determining the sample size in estimation of problems involving means:
  (a) *The variability of the population:* It would be seen that the higher the variability as measured by the population standard deviation, larger will be the size of the sample. If the standard deviation of the population is unknown, a researcher may use the estimates of the standard deviation from previous studies. Alternatively, the estimates of the population standard deviation can be computed from the sample data.
  (b) *The confidence attached to the estimate:* It is a matter of judgement, how much confidence you want to attach to your estimate. Assuming a normal distribution, the higher the confidence the researcher wants for the estimate, larger will be sample size. This is because the value of the standard normal ordinate '*Z*' will vary accordingly. For a 90 per cent confidence, the value of '*Z*' would be 1.645 and for a 95 per cent confidence, the corresponding '*Z*' value would be 1.96 and so on (see Table 7.1). It would be seen later that a higher confidence would lead to a larger '*Z*' value.
  (c) *The allowable error or margin of error:* How accurate do we want our estimate to be is again a matter of judgement of the researcher. It will of course depend upon the objectives of the study and the consequence resulting from the higher inaccuracy. If the researcher seeks greater precision, the resulting sample size would be large.

Table 7.1 Area under Standard Normal Distribution between the Mean and Successive Value of Z

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4804	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

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7.4.1 Sample Size for Estimating Population Mean

The formula for determining the sample size in such a case is given by

$$n = \frac{Z^2\sigma^2}{e^2}$$

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Where $\bar{X} - \mu$ = e = Margin of error
n = Sample size
σ = Population standard deviation
Z = the value of standard normal ordinate

It may be noted from above that the size of the sample is directly proportional to the variability in the population and the value of Z for a confidence interval. It varies inversely with the size of the error. It may also be noted that the size of a sample does not depend upon the size of population.

Below is given a worked out example for the determination of a sample size.

Example 7.1: An economist is interested in estimating the average monthly household expenditure on food items by the households of a town. Based on past data, it is estimated that the standard deviation of the population on the monthly expenditure on food item is ₹30. With allowable error set at ₹7, estimate the sample size required at a 90 per cent confidence.

Solution:

90 per cent confidence $\Rightarrow$ $Z = 1.645$

e = ₹7

σ = ₹30

$$n = \frac{Z^2\sigma^2}{e^2}$$

$$= \frac{(1.645)^2(30)^2}{(7)^2}$$

$= 49.7025$

$= 50$ (approx.)

7.4.2 Determination of Sample Size for Estimating the Population Proportion

The formula for determining the sample size in such a case is given by

$$n = \frac{Z^2 pq}{e^2}$$

The above formula will be used if the value of population proportion (proportion of occurrence of the event) p is known. If, however, p is unknown, we substitute the maximum value of pq in the above formula. It can be shown that the maximum value of pq is 1/4 when $p = 1/2$ and $q = 1/2$.

Therefore, $$n = \frac{1}{4}\frac{Z^2}{e^2}$$

Let us consider two examples for determining a sample size while estimating the population proportion.

Example 7.2: A manager of a department store would like to study women's spending per year on cosmetics. He is interested in knowing the population proportion of women who purchase their cosmetics primarily from his store. If he wants to have a 90 per cent confidence of estimating the true proportion to be within ± 0.045, what sample size is needed?

Solution:

90 per cent confidence ⇒ $Z = 1.645$

$e = \pm .045$

$$n = \frac{1}{4}\frac{Z^2}{e^2}$$

$$= \frac{1}{4}\frac{(1.645)^2}{(0.45)^2}$$

$= 334.0772$

$= 335$ (approx.)

Example 7.3: A consumer electronics company wants to determine the job satisfaction levels of its employees. For this, they ask a simple question, 'Are you satisfied with your job?' It was estimated that no more than 30 per cent of the employees would answer yes. What should be the sample size for this company to estimate the population proportion to ensure a 95 per cent confidence in result, and to be within 0.04 of the true population proportion?

Solution:

95 per cent confidence ⇒ $Z = 1.96$

$e = 0.04$

$p = 0.3$

$q = 0.7$

$$n = \frac{z^2 pq}{e^2}$$

$$= \frac{(1.96)^2 \times 0.3 \times 0.7}{(0.04)^2}$$

$= 504.21$

$= 505$ (approx.)

Points to be noted for sample size determination

There are certain issues to be kept in mind before applying the formulas for the determination of sample size in this unit. First of all, these formulas are applicable

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for simple random sampling only. Further, they relate to the sample size needed for the estimation of a particular characteristic of interest. In a survey, a researcher needs to estimate several characteristics of interests and each one of them may require a different sample size. In case the universe is divided into different strata, the accuracy required for determining the sample size for each strata may be different. However, the present method will not able to serve the requirement. Lastly, the formulas for sample size must be based upon adequate information about the universe.

Check Your Progress

6. What are the factors on which is the size of a sample depends?
7. Mention the most commonly used approach for determining the size of sample.

7.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Sample is the subset of a population.
2. Sampling frame comprises of all the elements of a population with proper identification that is available to us for selection at any stage of sampling.
3. Simple random sampling the special case of probability sampling design where every element of the population has both known and equal change of being selected in the sample.
4. Convenience sampling is the sampling design which is often used in the pre-test phase of a research study as the pre-testing of a questionnaire.
5. Snowball sampling is generally used when it is difficult to identify the members of the desired population. Under this design each respondent, after being interviewed, is asked to identify one or more in the field.
6. The size of a sample depends upon the basic characteristics of the population, the type of information required from the survey and the cost involved.
7. The most commonly used approach for determining the size of the sample is the confidence interval approach.

7.6 SUMMARY

- Surveys are useful in information collection. The survey respondents should be selected using appropriate and right procedures. The process of selecting the right individuals, objects or events for the study is known as sampling.

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- An alternative to sample is census where each and every element of the population (universe) is examined. There are many advantages of sampling over complete enumeration. While estimating the population parameter using sample results, the researcher may incur two types of error—sampling and non-sampling error.
- The process of selecting samples from the population is referred to as sampling design. There are two types of sampling designs—probability sampling design and non-probability sampling design. Probability sampling designs are used in a conclusive research whereas non-probability sampling designs are appropriate for an exploratory research.
- There are four probability sampling designs—the simple random sampling with replacement, simple random sampling without replacement, systematic sampling and stratified random sampling.
- Under the non-probability sampling designs, there are convenience sampling, judgmental sampling and snowball sampling.

7.7 KEY WORDS

- **Convenience sampling:** The type of sampling in which the sample is selected as per the convenience of the investigator.
- **Census**: The enumeration of each and every element of population.
- **Element**: A single member of population.
- **Sampling design:** The process of selecting samples from a population.
- **Sampling error:** The error that occurs because of non-representativeness of the sample.

7.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Differentiate between sample and census.
2. Differentiate between the stratified random sampling and systematic sampling.
3. Why is judgemental sampling used in research? Can it result in more representative sample than a random sample?

Long-Answer Questions

1. Explain the various sources of non-sampling errors.
2. Explain the difference between simple random sampling with replacement and without replacement.

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3. Explain giving example why a random sample may not result into a representative sample.
4. Explain the factors that should be considered while selecting a sample for research.

7.9 FURTHER READINGS

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UNIT 8 DATA PROCESSING

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Structure

8.0 INTRODUCTION

In the last few units, you have learnt about the various aspects of data collection. The critical job of the researcher begins after the data has been collected. He has to use this information to assess whether he had been correct or incorrect while making certain assumptions in the form of the hypotheses at the beginning of the study. The raw data that has been collected must be refined and structured in such a format that it can lend itself to statistical enquiry. This process of preparing the data for an analysis is a structured and sequential process. The process starts by validating the measuring instrument, which could be a questionnaire or any other primary technique. This is followed by editing, coding, classifying and tabulating the obtained data.

In this unit we will learn these steps of preparing the data through editing, coding and tabulating, so that it is ready for any kind of statistical analysis, in order to achieve the research objectives we had made earlier.

8.1 OBJECTIVES

After going through this unit, you will be able to:

- Explain the significance and technique of data processing
- Construct codes both for structured and unstructured questionnaires following certain guidelines.
- Classifiy and tabulate data in the required format.

8.2 DATA EDITING

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Data editing is the process that involves detecting and correcting errors (logical inconsistencies) in data. After collection, the data is subjected to processing. Processing requires that the researcher must go over all the raw data forms and check them for errors. The significance of validation becomes more important in the following cases:

- In case the form had been translated into another language, expert analysis is done to see whether the meaning of the questions in the two measures is the same or not.
- The second case could be that the questionnaire survey has to be done at multiple locations and it has been outsourced to an outside research agency.
- The respondent seems to have used the same response category for all the questions; for example, there is a tendency on a five point scale to give 3 as the answer for all questions.
- The form that is received back is incomplete, in the sense that either the person has not filled the answer to all questions, or in case of a multiple-page questionnaire, one or more pages are missing.
- The forms received are not in the proportion of the sampling plan. For example, instead of an equal representation from government and private sector employees, 65 per cent of the forms are from the government sector. In such a case the researcher either would need to discard the extra forms or get an equal number filled-in from private sector employees.

Once the validation process has been completed, the next step is the editing of the raw data obtained. While carrying out the editing the researcher needs to ensure that:

- The data obtained is complete in all respects.
- It is accurate in terms of information recorded and responses sought.
- Questionnaires are legible and are correctly deciphered, especially the open-ended questions.
- The response format is in the form that was instructed.
- The data is structured in a manner that entering the information will not be a problem.

The editing process is carried out at two levels, the first of these is field editing and the second is central editing.

8.2.1 Field Editing

Usually, the preliminary editing of the information obtained is done by the field investigators or supervisors who review the filled forms for any inconsistencies,

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non-response, illegible responses or incomplete questionnaires. Thus the errors can be corrected immediately and if need be the respondent who filled in the form, can be contacted again. The other advantage is that regular field editing ensures that one can also check that the surveyor is able to handle the process of instructions and probing correctly or not. Thus, the researcher can advise and train the investigator on how to administer the questionnaire correctly.

8.2.2 Centralized in-house Editing

The second level of editing takes place at the researcher's end. At this stage there are two kinds of typical problems that the researcher might encounter.

First, one might detect an incorrect entry. For example, in case of a five-point scale one might find that someone has used a value more than 5. In another case, one might be asking a question like, 'how many days do you travel out of the city in a week?' and the person says '15 days'. Here one can carry out a quick frequency check of the responses; this will immediately detect an unexpected value.

The second and the major problem that most researchers face is that of 'armchair interviewing' or a fudged interview. One way to handle this is to first scroll the answers to the open-ended questions, as generally if the investigator is filling in multiple forms faking these would be difficult.

The researcher has some standard processes available to him to carry out the editing process. These are briefly discussed below.

Backtracking: The best and the most efficient way of handling unsatisfactory responses is to return to the field, and go back to the respondents. This technique is best used for industrial surveys but a little difficult in individual surveys.

Allocating missing values: This is a contingency plan that the researcher might need to adopt in case going back to the field is not possible. Then the option might be to assign a missing value to the blanks or the unsatisfactory responses. However, this works in case:

- The number of blank or wrong answers is small.
- The number of such responses per person is small.
- The important parameters being studied do not have too many blanks, otherwise the sample size for those variables becomes too small for generalizations.

Plug value: In cases such as the third condition above, when the variable being studied is the key variable, then sometimes the researcher might insert a *plug value*. Sometimes one can plug an average or a neutral value in such cases, for example a 3 for a five-point scale or the researcher might have to establish a rule as to what value will be put if the person has not answered. Sometimes, the respondents' pattern of responses to other questions is used to extrapolate and calculate an appropriate response for the missing answer.

Discarding unsatisfactory responses: If the response sheet has too many blanks/illegible or multiple responses for a single answer, the form is not worth correcting and editing. Hence, it is much better to completely discard the whole questionnaire.

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Check Your Progress

1. What are the levels at which the editing of the raw data takes place?
2. Mention one way of handling the problem of 'armchair interviewing' or a fudged interview.

8.3 CODING

The process of identifying and denoting a numeral to the responses given by a respondent is called *coding*. This is essentially done in order to help the researcher's in recording the data in a tabular form later. It is advisable to assign a numeric code even for the categorical data (e.g., gender). In fact, even for open-ended questions, which are in a statement form, we will try to categorize them into numbers. The reason for doing this is that the graphic representation of data into charts and figures becomes easier.

Usually, the codes that have been formulated are organized into fields, records and files. For example, the gender of a person is one *field* and the codes used could be 0 for males and 1 for females. All related fields, for example, all the demographic variables like age, gender, income, marital status and education could be one *record*. The records of the entire sample under study form a single *file*. The data that is entered in the spreadsheet, such as on EXCEL, is in the form of a data matrix, which is simply a rectangular arrangement of the data in rows and columns. Here, every row represents a single case or record. For example, consider the following representation from a study on two-wheeler buyers (Table 8.1):

Table 8.1 *Sample Record: Excel Sheet for Two-wheeler Owners*

Unit Column 1	Occupation Column 2	Vehicle Column 3	Km/day Column 4	Marital status Column 5	Family size Column 6
1	4	1	20	1	3
2	3	2	25	2	1
3	5	1	25	1	4
4	2	1	15	2	2
5	4	2	20	2	4

Here, the data matrix reveals that each field is denoted on the column head and each case record is to be read along the row. The data in the first column represents the unique identification given to a particular respondent (also marked on his/her questionnaire). The second column has data entered on the basis of a coding scheme where every occupation is given a number value (for example, 1

stands for government service and 5 stands for student and so on). Column 3 has 1 representing a motorcycle and 2 representing a scooter. The next value is of the average number of kilometres a person travels per day.

This is followed by the marital status, with 1 signifying unmarried and 2 married. The last column is again a ratio scale data with the number of family members. The researcher can enter the data on the spreadsheet of the software package he/she is using for the analysis.

Codebook formulation: In order to manage the data entry process, it is best to prepare a method for entering the records. This coding scheme for all the variables under study is called a *code book*. Generally, while designing the rules, care must be taken to decide on some categories that are:

- ***Comprehensive:*** Should cover all the possible answer to the question that was asked.
- ***Mutually exclusive:*** The categories and codes devised must be exclusive or clearly different from each other.
- ***Single variable entry:*** The response that is being entered and the code for it should indicate only a single variable. For example, a 'working single mother' might seem an apparently simple category which one could code as 'occupation'. However, it needs three columns—occupation, marital status and family life cycle. So, one needs to have three different codes to enter this information.

Based on the above rules, one creates a code book. This would generally contain information on the question number, variable name, response descriptors and coding instructions and the column descriptor.

As we have read in Unit 6, a questionnaire can have both closed-ended and open-ended questions. When the questions are structured and the response categories are prescribed then one does what is called *pre-coding*, i.e., giving numeral codes to the designed responses *before* administration. However, if the questions are structured and the answers are open ended, one needs to decide on the codes *after* the administration of the survey. This is called *post-coding*.

8.3.1 Coding Closed-ended Structured Questions

The method of coding for structured questions is easier as the response categories are decided in advance. The coding method to be followed for different kinds of questions is discussed below.

Dichotomous questions: For dichotomous questions, which are on a nominal scale, the responses can be binary, for example:

Do you eat ready-to-eat food? Yes = 1; no = 0.

This means if someone eats ready- to- eat food he/she will be given a score of 1 and if not, then 0.

Table 8.2 Codebook Extract for Ready-to-eat Food Study

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Question No.	Variable Name	Coding Instruction	Symbol used for Variable Name
1.	Buy ready-to-eat food products	Yes = 1 No = 0	X1
2.	Use ready-to-eat food products	Yes = 1 No = 0	X2
22.	Age	Less than 20 years = 1, 21–26 years = 2, 27–35 years = 3, 36–45 years = 4, More than 45 years = 5	X22
23.	Gender	Male = 1 Female = 2	X23
24.	Marital status	Single = 1 Married = 2 Divorced/widow = 3	X24
25.	No. of children	Exact no. to be written	X25

Ranking questions: For ranking questions where there are multiple objects to be ranked, the person will have to make multiple columns, with column numbers equaling the number of objects to be ranked. For example, for ranking TV serials, the code book would be as follows:

Q.No.	Variable Name	Coding Instructions	Variable Name
1.	*Balika Vadhu*	Number from 1-10	X 10a
2.	*Sathiya*	Number from 1-10	X 10b
3.	*Sasural Genda Phool*	Number from 1-10	X 10c
4.	*Bidai*	Number from 1-10	X 10d
5.	*Pathshala*	Number from 1-10	X 10e

Checklists/multiple responses: In questions that permit a large number of responses, each possible response option should be assigned a separate column. For example, consider the following question:

Which of the following newspapers do you read? (Tick all that you read.)

Times of India ________________

Hindustan Times ________________

Mail Today ________________

Indian Express ________________

Deccan Chronicle ________________

Asian Age ________________

Mint ________________

For this question, the number of columns required is seven, one for each newspaper. The coding instructions for each column would be as follows: in case the person ticks on a name, the paper = 1, and in case he does not tick, the paper = 0.

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Scaled questions: For questions that are on a scale, usually an interval scale, the question/statement will have a single column and the coding instruction would indicate what number needs to be allocated for the response options given in the scale. Consider the following questions.

Please indicate level of your agreement with the following statements.

	Compared to the Past (5-10 years)	SA	A	N	D	SD
1	The individual customer today shops more					
2	The consumer is well informed about market offerings					

SA – Strongly agree; *A* – Agree; *N* – Neutral; *D* – Disagree; *SD* – Strongly disagree

The code book for this will look as follows:

Col.no.	Variable Name	Coding Instructions	Variable Name
1.	Individual shops more	A number from 1–5 SA = 5, A = 4, N = 3, D = 2, SD = 1	X 1a
2.	Well informed	- do -	X 1b

Missing values: It is advisable to use a standard format for signifying a non-response or a missing value. For example, a code of 9 could be used for a single-column variable, 99 for a double-column variable, and 999 for a three character variable and so on. The researcher must take care as far as possible to use a value that is starkly different from the valid responses. This is one of the reasons why 9 is suggested. However, in case you have a 10 point scale do not use 9 .

8.3.2 Coding Open-ended Structured Questions

The coding of open-ended questions is quite difficult as the respondents' exact answers are noted on the questionnaire. Then the researcher (either individually or as a team) looks for patterns and assigns a category code.

The following example is an open ended question

If you think lean management was a success so far, please specify three most significant reasons that have contributed to its success in your opinion.

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People gave different answers. Thus, based upon the responses obtained, for the above question, the following post–code book was created:

Col.No.	Variable Name	Coding Instructions	Variable Name
63	Improvement at workplace by eliminating waste.	Yes = 1 No = 0	X 63a
64	To meet increasing demands of customers	Yes = 1 No = 0	X 63b
65	To improve quality	Yes = 1 No = 0	X 63c
66	To achieve corporate goal	Yes = 1 No = 0	X 63d

8.4 CLASSIFICATION AND TABULATION OF DATA

Sometimes, the data obtained from the primary instrument is so huge that it becomes difficult to interpret. In such cases, the researcher might decide to reduce the information into homogenous categories. This method of arrangement is called classification of data. This can be done on the basis of class intervals.

Classification by class intervals: Numerical data, like the ratio scale data, can be classified into *class intervals*. This is to assist the quantitative analysis of data. For example, the age data obtained from the sample could be reduced to homogenous grouped data, for example all those below 25 form one group, those 25–35 are another group and so on. Thus, each group will have class limits—an upper and a lower limit. The difference between the limits is termed as the class magnitude. One can have class intervals of both equal and unequal magnitude.

The decision on how many classes and whether equal or unequal depends upon the judgement of the researcher. Generally, multiples of 2 or 5 are preferred. Some researchers adopt the following formula for determining the number of class intervals:

$$I = R/(1 + 3.3 \log N)$$

where,

I = size of class interval,

R = Range (i.e., difference between the values of the largest item and smallest item among the given items),

N = Number of items to be grouped.

The class intervals that are decided upon could be *exclusive*, for example:

10–15

15–20

20–25

25–30

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In this case, the upper limit of each is excluded from the category. Thus we read the first interval above as 10 and under 15, the next one as 15 and under 20 and so on.

The other kind is *inclusive*, that is:

10–15

16–20

21–25

26–30

Here, both the lower and the upper limits are included in the interval. It says 10–15 but actually means 10–15.99. It is recommended that when one has continuous data it should be signified as 10–15.99, as then all possibilities of the responses are exhausted here. However, for discrete data one can use 10–15.

Once the categories and codes have been decided upon, the researcher needs to arrange the same according to some logical pattern. This is referred to as ***tabulation*** of data. This involves an orderly arrangement of data into an array that is suitable for a statistical analysis. Usually, this is an orderly arrangement of the rows and columns. In case there is data to be entered for one variable, the process is a simple tabulation and, when it is two or more variables, then one carries out a cross-tabulation of data. The method of cross-tabulating the data is discussed at length in Unit 12.

Check Your Progress

3. What does a code book contain?
4. How is coding done for scaled questions?
5. What is class magnitude?

8.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The editing of the raw data takes place at two levels, the first of these is field editing and the second is central editing.
2. One way to handle the problem of 'armchair interviewing' or a fudged interview is to first scroll the answers to the open-ended questions, as generally if the investigator is filling in multiple forms faking these would be difficult.
3. A code book contains information on the question number, variable name, response descriptors, and coding instructions and the column descriptor.

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4. For questions that are on a scale, usually an interval scale, the question/statement will have a single column and the coding instruction would indicate what number needs to be allocated for the response options given in the scale.
5. In the class interval, each group has a lower and a upper limit. The difference between the limits is termed as the class magnitude.

8.6 SUMMARY

- Data processing refers to the primary data that has been collected specifically for the study.
- The researcher has to check for omissions or errors .This is the editing stage of the data processing step. This is done first at the field and then at the central office level.
- At this stage, the research team conducts some data treatment such as allocating the missing values, if possible, backtracking and sometimes, plugging the incomplete data.
- Once this is completed, the researcher prepares code book. Classification into attributes or class intervals is carried out and the entered data is now ready for analysis in a tabular form.

8.7 KEY WORDS

- **Backtracking:** The best and the most efficient way of handling unsatisfactory responses is to return to the field, and go back to the respondents.
- **Code book: C**oding scheme for all the variables under study
- **Coding** The process of identifying and denoting a numeral to the responses given by a respondent is called
- **Data tabulation:** Arrangement of data according to some logical pattern

8.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is data editing? Mention its significance.
2. Distinguish between field editing and centralized in-house editing. Mention the standard processes available to the researcher to carry out the editing process.

Long-Answer Questions

1. How do you code data? What guidelines should be followed to carry out the task? Discuss by giving suitable examples.
2. Distingush between coding closed-ended structured questions and coding open-ended structured questions.
3. Explain the classification and tabulation of data.

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8.9 FURTHER READINGS

Burns, Robert B. 2000. *Introduction to Research Methods.* London: Sage Publications.

Chawla D and Sondhi N. 2016. *Research Methodology: Concepts and Cases*, 2nd edition. New Delhi: Vikas Publishing House.

Kothari, C R. 1990. *Research Methodology: Methods and Techniques*, 2nd edn. New Delhi: Wiley Eastern Ltd.

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UNIT 9 UNIVARIATE AND BIVARIATE ANALYSIS OF DATA

Structure

9.0 INTRODUCTION

In the previous unit, we studied the processing of data collected from both primary and secondary sources. The next step is to analyse the same so as to draw logical inferences from them. The data collected in a survey could be voluminous in nature, depending upon the size of the sample. In a typical research study there may be a large number of variables that the researcher needs to analyse. The analysis could be univariate, bivariate and multivariate in nature. In the univariate analysis, one variable is analysed at a time. In bivariate analysis, two variables are analysed together and examined for any possible association between them. In multivariate analysis, the concern is to analyse more than two variables at a time.

In this unit, we will concentrate on the descriptive analysis of univariate and bivariate data

9.1 OBJECTIVES

After going through this unit, you will be able to:

- Distinguish between univariate, bivariate and multivariate analysis.

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- Differentiate between descriptive and inferential analysis.
- Discuss the type of descriptive univariate analysis to be carried on nominal, ordinal, interval and ratio scale data.
- Explain the descriptive analysis of bivariate data.

9.2 DESCRIPTIVE VS INFERENTIAL ANALYSIS

At the data analysis stage, the first step is to describe the sample which is followed by inferential analysis. In the descriptive analysis, we describe the sample whereas the inferential analysis deals with generalizing the results as obtained from the sample.

9.2.1 Descriptive Analysis

Descriptive analysis refers to transformation of raw data into a form that will facilitate easy understanding and interpretation. Descriptive analysis deals with summary measures relating to the sample data. The common ways of summarizing data are by calculating average, range, standard deviation, frequency and percentage distribution. Below is a set of typical questions that are required to be answered under descriptive statistics:

- What is the average income of the sample?
- What is the standard deviation of ages in the sample?
- What percentage of sample respondents are married?
- What is the median age of the sample respondents?
- Which income group has the highest number of user of product in question in the sample?
- Is there any association between the frequency of purchase of product and income level of the consumers?

Types of descriptive analysis

The type of descriptive analysis to be carried out depends on the measurement of variables into four forms—nominal, ordinal, interval and ratio.

Table 9.1 presents the type of descriptive analysis which is applicable under each form of measurement.

Table 9.1 *Descriptive Analysis for Various Levels of Measurement*

Type of Measurement	Type of Descriptive Analysis
Nominal	Frequency table, Proportion percentages, Mode
Ordinal	Median, Quartiles, Percentiles, Rank order correlation
Interval	Arithmetic mean, Correlation coefficient
Ratio	Index numbers, Geometric mean, Harmonic mean

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9.2.2 Inferential Analysis

After descriptive analysis has been carried out, the tools of inferential statistics are applied. Under inferential statistics, inferences are drawn on population parameters based on sample results. The researcher tries to generalize the results to the population based on sample results. The analysis is based on probability theory and a necessary condition for carrying out inferential analysis is that the sample should be drawn at random. The following is an illustrative list of questions that are covered under inferential statistics.

- Is the average age of the population significantly different from 35?
- Is the job satisfaction of unskilled workers significantly related with their pay packet?
- Do the users and non-users of a brand vary significantly with respect to age?
- Does the advertisement expenditure influences sale significantly?
- Are consumption expenditure and disposable income of households significantly correlated?
- Is the proportion of satisfied workers significantly more for skilled workers than for unskilled works?

Check Your Progress

1. What are some of the common ways of summarizing data?
2. What is inferential analysis based on? State its necessary condition.

9.3 DESCRIPTIVE ANALYSIS OF UNIVARIATE DATA

The first step under univariate analysis is the preparation of frequency distributions of each variable. The frequency distribution is the counting of responses or observations for each of the categories or codes assigned to a variable.

9.3.1 Analysis of Nominal Scale Data with only One Possible Response

Consider a nominal scale variable—gender of respondents in a survey research.

Table 9.2 shows both the raw frequency and the percentages of responses for each category in case of the variable gender in a sample of 414 respondents.

Table 9.2 Gender of the respondent

		Frequency	Per cent	Valid Per cent	Cumulative Per cent
Valid	Male	301	72.7	72.7	72.7
	Female	113	27.3	27.3	100.0
	Total	414	100.0	100.0	

This tabulation process can be done by hand, using tally marks. The results indicate that out of a sample of 414 respondents, 301 are male and 113 are female. The raw frequencies are often converted into percentages as they are more meaningful. In the present case, for example, there are 72.7 per cent male and 27.3 per cent female respondents.

9.3.2 Analysis of Nominal Scale Data with Multiple Category Responses

In section 9.3.1 the variable considered could take only two values, namely, male and female and one of the two responses was possible. However, at times, the researcher comes across multiple-category questions, where respondents could choose more than one answer. In such a case, the preparation of frequency table and its interpretation is slightly different. If the question in the research study is multiple category question and the responds are allowed to tick more than one choice, the percentage in such a case may not add up to 100. For example, one may consider the following question:

When accessing the internet at a cyber cafe, tick up to four frequently used applications for which you use the cyber cafe.

1. E-mail
2. Chat
3. Browsing
4. Downloading
5. Shopping
6. Net telephony
7. Business and Commerce (e-commerce)
8. Entertainment
9. Adult sites
10. Astrology and Horoscope
11. Education
12. Any other, please specify.

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The coding for the variable applications has been in binary form where values one and zero are assigned. If the respondent uses a particular application, the value assigned is 1, otherwise 0. The resulting frequency table for the above-mentioned question is as presented in Table 9.3.

Table 9.3 *Frequently used Applications at Cyber Cafe*

Sl. No.	Application	Frequencies	Percentage (%)
1	Email	399	94.9
2	Chat	316	76.3
3	Browsing	232	56
4	Downloading	197	47.6
5	Shopping	30	7.2
6	Net telephony	30	7.2
7	E-commerce	51	12.3
8	Entertainment	135	32.6
9	Adult sites	59	14.3
10	Astrology and horoscopes	52	12.6
11	Education	159	38.4
12	Any Other	14	3.4
TOTAL RESPONDENTS		414	

*Total exceeds 100% because of multiplicity of answers.

In Table 9.3 the percentages are computed on the total sample size of 414. If these percentages are added up, they would exceed more than 100 per cent. This is because of multiplicity of answers as respondents were given the chance to choose more than one answer. The interpretation of the table would be based on a sample of 414 and is given as:

- The most used application at a cyber cafe is e-mail. It is seen that 94.9 per cent of the users make use of this.
- The second popular application is chatting, and 76.3 per cent of the sample respondents make use of it.
- Similarly, other applications in order of preference are browsing (56 per cent), downloading (47.6 per cent), education 35.4 per cent), entertainment (32.6 per cent) and so on.

9.3.3 Analysis of Ordinal Scaled Questions

There could always be some ordinal-scaled questions in the questionnaire. The question before the researcher is how to tabulate and interpret the responses to such questions. It could be done in two ways as would be shown in the following example. The questions asked of the respondents in such a case could be:

- Rank the following five attributes while choosing a restaurant for dinner. Assign a rank of 1 to the most important, 2 to the next important … and 5 to the least important.

– Ambience
– Food quality
– Menu variety
– Service
– Location

From a sample of 32, the responses obtained are given in Table 9.4. To construct univariate tables out of the given data, one can take up one column at a time from Table 9.4 and prepare the separate frequency tables. For example, distribution of rank assigned to attribute food quality may be considered in Table 9.5.

Table 9.4 *Ranking of Various Attributes while Selecting a Restaurant for Dinner*

Respondent No.	Ambience	Food Quality	Menu Variety	Service	Location
1	3	1	4	2	5
2	5	2	1	4	3
3	1	2	5	3	4
4	3	1	5	2	4
5	2	1	5	3	4
6	1	3	2	4	5
7	3	2	4	1	5
8	1	2	5	3	4
9	4	2	3	5	1
10	4	3	1	2	5
11	2	1	5	3	4
12	5	1	4	3	2
13	3	1	5	4	2
14	4	1	2	5	3
15	3	2	5	1	4
16	1	2	5	4	3
17	3	1	4	2	5
18	5	2	1	3	4
19	2	1	4	3	5
20	3	2	4	5	1
21	4	1	5	2	3
22	3	2	1	4	5
23	5	1	4	3	2
24	3	2	5	1	4
25	5	1	4	3	2
26	2	1	3	5	4
27	3	1	4	2	5
28	3	2	1	4	5
29	3	1	5	2	4
30	4	2	1	3	5
31	2	1	5	3	4
32	3	4	1	2	5

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Table 9.5 Distribution of Ranks Assigned to Food Quality

Rank	Frequency	Per cent
1	16	50.0
2	13	40.6
3	2	6.3
4	1	3.1
5	—	—
Total	32	100.0

It is seen from Table 9.5 that out of 32 respondents, 16 (50 per cent) have assigned rank one, 13 (40.6 per cent) ranked two, 2 (6.3 per cent) ranked three and 1 (3.1 per cent) ranked four to food quality. This shows that food quality is given a lot of importance by the respondents. Similar analysis could be carried out for other attributes.

The other way of preparing a univariate table could be to find distribution of attribute which got various ranks. Table 9.6 indicates the distribution of attributes that received rank one.

Table 9.6 Distribution of Attributes that Received Rank One

Attribute	Number	Percentage
Ambience	4	12.50
Food Quality	16	50.00
Menu Variety	7	21.88
Service	3	9.38
Location	2	6.25
Total	32	100

Table 9.6 indicates that 50 per cent of the respondents gave food quality rank one, whereas 21.88 per cent gave menu variety as rank one, followed by ambience that was ranked one by 12.5 per cent of the respondents. Similar analysis could be carried out corresponding to the remaining attributes.

The ordinal scale data could also be used for preparing a summarized rank order. For example, data presented in Table 9.4 gives the ranking by 32 respondents on five attributes while choosing a restaurant for dinner. The data given in Table 9.4 can be used to prepare the summarized rank ordering of various attributes. The rankings of attributes given in Table 9.4 can be presented in the form of frequency distribution in Table 9.7.

Table 9.7 Frequency Table of the Rankings of the Attributes while Selecting a Restaurant for Dinner

Attribute	Rank				
	1	2	3	4	5
Ambience	4	5	13	5	5
Food Quality	16	13	2	1	0
Menu Variety	7	2	2	9	12
Service	3	8	11	6	4
Location	2	4	4	11	11
Total	**32**	**32**	**32**	**32**	**32**

To calculate a summary rank ordering, the attribute with the first rank was given the lowest number (1) and the least preferred attribute was given the highest number (5).

The summarized rank order is obtained with the following computations as:

Ambience	:	(4 × 1) + (5 × 2) + (13 × 3) + (5 × 4) + (5 × 5)	=	98
Food Quality	:	(16 × 1) + (13 × 2) + (2 × 3) + (1 × 4) + (0 × 5)	=	52
Menu Variety	:	(7 × 1) + (2 × 2) + (2 × 3) + (9 × 4) + (12 × 5)	=	113
Service	:	(3 × 1) + (8 × 2) + (11 × 3) + (6 × 4) + (4 × 5)	=	96
Location	:	(2 × 1) + (4 × 2) + (4 × 3) + (11 × 4) + (11 × 5)	=	121

The total lowest score indicates the first preference ranking. The results show the following rank ordering:

(1) Food quality

(2) Service

(3) Ambience

(4) Menu variety

(5) Location

9.3.4 Measures of Central Tendency

There are three measures of central tendency that are used in research—mean, median and mode.

1. Mean

The mean represents the arithmetic average of a variable is appropriate for interval and ratio scale data. The mean is computed as:

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

NOTES

Where,

$\bar{X}$ = Mean of some variable X

X_i = Value of i[th] observation on that sample

n = Number of observations in the sample

It is also possible to compute the value of mean when interval or ratio scale data are grouped into categories or classes. The formula for mean in such a case is given by:

$$\bar{X} = \frac{\sum_{i=1}^{k} f_i X_i}{n}$$

Where,

f_i = Frequency of i[th] class

X_i = Midpoint of i[th] class

k = Number of classes

Given below are two examples to illustrate the computation of arithmetic mean:

Example 9.1: The percentage of dividend declared by a company over the last 12 years is 5, 8, 6, 10, 12, 20, 18, 15, 30, 25, 20, 16. Compute the average dividend.

Solution:

Let X_i denote the dividend declared in ith year;

$$\sum X_i = 185 \; \bar{X} = \frac{\sum X_i}{n} = 15.417$$

Therefore, the average dividend declared by the company in the last 12 years is 15.417 per cent.

Example 9.2: The sales data of 250 retail outlets in the garment industry gave the following distribution. Compute the arithmetic mean of the sales.

Sales (in ₹ lakh)	No. of firms
0–20	6
20–40	16
40–60	34
60–80	46
80–100	75
100–120	42
120–140	20
140–160	11
Total	**250**

Solution:

Sales (in ₹ lakh)	No. of firms (f)	Mid-point (X)	$X \times f$
0–20	6	10	60
20–40	16	30	480
40–60	34	50	1700
60–80	46	70	3220
80–100	75	90	6750
100–120	42	110	4620
120–140	20	130	2600
140–160	11	150	1650
Total	**250**		**21080**

$$\sum X_i f_i = 21080 \quad \bar{X} = \frac{\sum X_i f_i}{\sum f_i} = \frac{21080}{250} = 84.32$$

Hence, the average sales of 250 retail outlets in the garments industry is ₹84.32 lakh. The main limitation of arithmetic mean as a measure of central tendency is that it is unduly affected by extreme values. Further, it cannot be computed with open-ended frequency distribution without making assumptions regarding the size of the class interval of the open-ended classes. In an extremely asymmetrical distribution, it is not a good measure of central tendency.

2. Median

The median can be computed for ratio, interval or ordinal scale data. The median is that value in the distribution such that 50 per cent of the observations are below it and 50 per cent are above it. The median for the ungrouped data is defined as the middle value when the data is arranged in ascending or descending order of magnitude. In case the number of items in the sample is odd, the value of $(n + 1)/2^{\text{th}}$ item gives the median. However if there are even number of items in the sample, say of size $2n$, the arithmetic mean of n^{th} and $(n + 1)^{\text{th}}$ items gives the median. It is again emphasized that data needs to be arranged in ascending or descending order of the magnitude before computing the median.

Given below are a few examples to illustrate the computation of median:

Example 9.3: The marks of 21 students in economics are given 62, 38, 42, 43, 57, 72, 68, 60, 72, 70, 65, 47, 49, 39, 66, 73, 81, 55, 57, 57, 59. Compute the median of the distribution.

Solution:

By arranging the data in ascending order of magnitude, we obtain: 38, 39, 42, 43, 47, 49, 55, 57, 57, 57, 59, 60, 62, 65, 66, 68, 70, 72, 72, 73, 81.

The median will be the value of the 11$^{\text{th}}$ observation arranged as above. Therefore, the value of median equals 59. This means 50 per cent of students score marks below 59 and 50 per cent score above 59.

Example 9.4: What would be the median score in the above example if there were 22 students in the class and the score of the 22$^{\text{nd}}$ student was 79.

NOTES

Solution:

By arranging the data in ascending order of magnitude, we obtain: 38, 39, 42, 43, 47, 49, 55, 57, 57, 57, 59, 60, 62, 65, 66, 68, 70, 72, 72, 73, 79, 81.

The median is given by the average of 11th and 12th observation when arranged in ascending order of magnitude.

The value of 11^{th} observation = 59.

The value of 12^{th} observation = 60.

Mean of 11^{th} and 12^{th} observation = (59 + 60)/2 = 59.5.

Hence 50 per cent of the students score marks below 59.5 per cent and 50 per cent score above 59.5.

The median could also be computed for the grouped data. In that case first of all, median class is located and then median is computed using interpolation by using the assumption that all items are evenly spread over the entire class interval. The median for the grouped data is computed using the following formula

$$\text{Median} = l + \frac{\frac{N}{2} - CF}{f} \times h$$

Where

l = Lower limit of the median class

f = Frequency of the median class

CF = Cumulating frequency for the class immediately below the class containing the median

h = Size of the interval of the median class.

N = Sum total of all frequencies

Given below is an example to illustrate the computation of median in the case of grouped data:

Example 9.5: The distribution of dividend declared by 77 companies is given in the following table. Compute the median of the distribution.

Percentage of dividend declared	Number of Companies
0–10	6
10–20	8
20–30	23
30–40	18
40–50	14
50–60	6
60–70	2
Total	**77**

Solution:

Percentage of dividend declared	Number of Companies (f)	CF
0–10	6	6
10–20	8	14
20–30	23	37
30–40	18	55
40–50	14	69
50–60	6	75
60–70	2	77
Total	**77**	

$$\text{Median} = l + \frac{\frac{N}{2} - CF}{f} \times h$$

Where

l = Lower limit of the median class = 30

f = Frequency of the median class = 18

CF = Cumulating frequency for the class immediately below the class containing the median = 37

h = Size of the interval of the median class = 10

N = Sum total of all frequencies

Substituting these values in the formula for median, we get

Median = 30.83

The results show that half of the companies have declared less than 30.83 per cent dividend and the other half have declared more than 30.83 per cent dividend.

The limitations of median as a measure of central tendency is that it does not use each and every observation in its computation since it is a positional average.

3. Mode

The mode is that measure of central tendency which is appropriate for nominal or higher order scales. It is the point of maximum frequency in a distribution around which other items of the set cluster densely. Mode should not be computed for ordinal or interval data unless these data have been grouped first. The concept is widely used in business, e.g. a shoe store owner would be naturally interested in knowing the size of the shoe that the majority of the customers ask for. Similarly, a garment manufacturer is interested in determining the size of the shirt that fits most people so as to plan its production accordingly.

Example 9.6: The marks of 20 students of a class in statistics are given as under:

44, **52**, 40, 61, 58, **52**, 63, 75, 87, **52**, 63, 38, 44, 61, 68, 75, 72, **52**, 51, 50,

Solution:

It is observed that the maximum number of students (four) have obtained 52 marks. Therefore, the mode of the distribution is 52.

NOTES

In the case of grouped data, the following formula may be used:

$$\text{Mode} = l + \frac{f - f_1}{2f - f_1 - f_2} \times h$$

Where,

l = Lower limit of the modal class

f_1, f_2 = The frequencies of the classes preceding and following the modal class respectively.

f = Frequency of modal class

h = Size of the class interval

Given below is an example to illustrate the computation of mode in a grouped data:

Example 9.7: The data in the following frequency distribution is about monthly wages of semi-skilled worker in a town. Compute the modal wage.

Monthly wage (₹)	Number of workers
5000–6000	15
6000–7000	20
7000–8000	24
8000–9000	32
9000–10000	28
10000–11000	20
11000–12000	16
Total	**155**

Solution:

The mode is given by the formula

$$\text{Mode} = l + \frac{f - f_1}{2f - f_1 - f_2} \times h$$

Where

l = Lower limit of the modal class = 8000

f_1, f_2 = The frequencies of the classes preceding and following the modal class respectively = 24, 28

f = Frequency of modal class = 32

h = Size of the class interval = 1000

$$\text{Mode} = 8000 + \frac{32 - 24}{64 - 24 - 28} \times 1000 = 8666.7$$

Hence, modal wages are ₹8666.7.

Another important concept is skewness, which measures lack of symmetry in the distribution. In case of symmetrical distribution, mean = median = mode. For a positively skewed distribution, mean > median > mode. In such a case, the longer tail of the distribution is towards the right, the mode falls under the peak and the mean changes its position as it is affected by extreme values. The same is the case with negatively skewed distribution where arithmetic mean < median < mode.

The skewness is measured by the difference between arithmetic mean and mode. If the value of arithmetic mean is greater than mode, skewness is positive and if the value of the expression is negative, skewness is negative.

9.3.5 Measures of Dispersion

The measures of central tendency locate the centre of the distribution. However, they do not provide enough information to the researcher to fully understand the distribution being examined. There is a need to study the spread of a distribution of a variable and the methods which provide that are called measures of dispersion.

The study of dispersion could help in taking better decisions. This is because small dispersion indicates high uniformity of the items, whereas large variability denotes less uniformity. If returns on a particular investment show lot of variability (dispersion), it means a risky investment as compared to the one where variability is very small. The various measures of dispersion are discussed below:

(i) **Range:** This is the simplest measure of dispersion and is defined as the distance between the highest (maximum) value and the lowest (minimum) value in an ordered set of values. The range could be computed for interval scale and ratio scale data.

$$\text{Range} = X_{\max} - X_{\min}$$

Where,

$X_{\max}$ = Maximum value of the variable

$X_{\min}$ = Minimum value of the variable

The limitation of range as a measure of dispersion is that it considers only the extreme value and ignores all other data points. The value of range could vary considerably from sample to sample. Even with this limitation, range as a measure of dispersion is widely used in industrial quality control for the preparation of control charts.

Example 9.8: The following are the prices of shares of a company from Monday to Friday: Calculate the range of the distribution.

Day	Price (₹)
Monday	125
Tuesday	180
Wednesday	100
Thursday	210
Friday	150

Solution:

L = Largest values = 210

S = Smallest value = 100

NOTES

Therefore, range = $L - S$ = 210 – 100 = 110.

In the case of a frequency distribution, range is calculated by taking the difference between the lower limit of the lowest class and upper limit of the highest class. The limitation of range is that it is not based on each and every observation of the distribution and, therefore, does not take into account the form of distribution within the range.

(ii) **Variance and standard deviation:** Variance is defined as the mean squared deviation of a variable from its arithmetic mean. The positive square root of the variance is called standard deviation. The variance is a difficult measure to interpret and, therefore, standard deviation is used as a measure of dispersion. The population standard deviation is denoted by σ and computed using the following formula:

$$\sigma = \sqrt{\frac{\Sigma(X-\mu)^2}{N}}$$

Where,

σ = Population standard deviation

X = Value of observations

μ = Population mean of observations

N = Total number of observations in the population.

However, in survey research, we generally take a sample from the population. If the standard deviation is computed from the sample data, the following formula may be used.

$$s = \sqrt{\frac{\Sigma(X-\bar{X})^2}{n-1}}$$

Where,

s = Sample standard deviation

$\bar{X}$ = Sample mean

X = Value of observation

n = Total number of observations in the sample

In case of grouped data, the following formula for computing sample standard deviation may be used:

$$s = \sqrt{\frac{\Sigma f_i(X_i-\bar{X})^2}{n-1}}$$

NOTES

Where,

X_i = Value of i^th^ observation

$\bar{X}$ = Sample mean

f_i = frequency of i^th^ class interval

n = sample size

The standard deviation could be computed in case of interval and ratio scale data.

Example 9.9: Sample data of 10 days' sales from the two-month data collected on daily basis is given below. Compute the sample variance and standard deviation.

Sales in unit	15	28	32	16	19	26	38	40	25	13

Solution:

Sales in unit (X)	$x = X - \bar{X}$	$(X - \bar{X})^2$
15	–10.2	104.04
28	2.8	7.84
32	6.8	46.24
16	–9.2	84.64
19	–6.2	38.44
26	0.8	0.64
38	12.8	163.84
40	14.8	219.04
25	–0.2	0.04
13	–12.2	148.84
Total	**0**	**813.6**

$$\Sigma X = 252$$

$$\bar{X} = \frac{\Sigma X}{n} = \frac{252}{10} = 25.2$$

$$\Sigma (X - \bar{X})^2 = 813.6$$

$$\text{Variance} = s^2 = \frac{\Sigma(X - X)^2}{n-1} = \frac{813.6}{9} = 90.4$$

$$\text{Standard deviation} = s = \sqrt{90.4} = 9.508$$

Therefore, the standard deviation of sales of 10 days is 9.508 units.

NOTES

Example 9.10: The data on dividend declared in percentage is presented in the following frequency distribution table for a sample of 107 companies. Compute the variance and standard deviation of the dividend declared.

Dividend declared (per cent)	Number of Companies
0–10	5
10–20	10
20–30	13
30–40	25
40–50	30
50–60	16
60–70	8
Total	**107**

Solution:

Dividend declared (per cent)	Number of Companies (f)	X	fX	$X-\bar{X}$	$(X-\bar{X})^2$	$f(X-\bar{X})^2$
0–10	5	5	25	– 33.5514	1125.697	5628.483
10–20	10	15	150	– 23.5514	554.6685	5546.685
20–30	13	25	325	– 13.5514	183.6405	2387.326
30–40	25	35	875	– 3.5514	12.61246	315.3114
40–50	30	45	1350	6.448598	41.58442	1247.533
50–60	16	55	880	16.4486	270.5564	4328.902
60–70	8	65	520	26.4486	699.5283	5596.227
Total			4125			**25050.47**

$$\Sigma fX = 4125$$

$$\bar{X} = \frac{\Sigma fX}{\Sigma f} = \frac{4125}{107} = 38.5514$$

$$\Sigma f(X-\bar{X})^2 = 25050.47$$

$$\text{Variance} = s^2 = \frac{\Sigma f(X-X)^2}{n-1} = \frac{25050.47}{106} = 236.3252$$

$$s = \text{Standard deviation} = \sqrt{236.3252} = 15.373$$

Therefore, the standard deviation of the dividend declared of 107 companies is 15.373 per cent.

(iii) **Coefficient of variation:** This measure is computed for ratio scale measurement. The standard deviation measures the variability of a variable around the mean. The unit of measurement of standard

deviation is the same as that of arithmetic mean of the variable itself. The measure of dispersion is considerably affected by the unit of measurement. In such a case, it is not possible to compare the variability of two distributions using standard deviation as a measure of variability. To compare the variability of two or more distributions, a measure of relative dispersion called the coefficient of variation can be used. This measure is independent of units of measurements. The formula of coefficient of variation is:

$$CV = \frac{s}{\bar{X}} \times 100$$

Where,

CV = coefficient of variation

s = standard deviation of sample

$\bar{X}$ = mean of the sample

Example 9.11: For the data given in Example 9.10, compute the coefficient of variation.

Solution:

$$CV = \frac{s}{\bar{X}} \times 100$$

Where,

CV = Coefficient of variation

s = Standard deviation of sample = 15.373

$\bar{X}$ = Mean of the sample = 38.5514

$$\text{Therefore, } CV = \frac{15.373 \times 100}{38.5514} = 39.88 \text{ per cent}$$

Therefore, the coefficient of variation is 39.88 per cent. As already mentioned, coefficient of variation is useful for comparing the variability of two distributions. This is a more useful measure when two distributions are entirely different and the units of measurements are also different.

Some more examples

Individual series

1. Find arithmetic mean of the following data.

   58 67 60 84 93 98 100

   Arithmetic mean = $\Sigma X/n$

Where,

ΣX = the sum of the item

N = the number of items in the series

ΣX = 58 + 67 + 60 + 84 + 93 + 98 + 100 = 560

N = 7

ΣX = 560/7 = 80

2. Find arithmetic mean of the following distribution.

2.0 1.8 2.0 2.0 1.9 2.0 1.8 2.3 2.5 2.3

1.9 2.2 2.0 2.3

Arithmetic mean = ΣX/n

Where,

ΣX = the sum of the item

n = the number of items in the series

ΣX = 2.0 + 1.8 + 2.0 + 2.0 + 1.9 + 2.0 + 1.8 + 2.3 + 2.5 + 2.3 + 1.9 + 2.2 + 2.0 + 2.3 = 29

N = 14

ΣX = 29/14=2.07

Discrete series

3. Calculate arithmetic mean of the following 50 workers according to their daily wages.

Daily Wages	:	15	18	20	25	30	35	40	42
Number of workers	:	2	3	5	10	12	10	5	2

Arithmetic mean using direct formula

Wages (X)	Frequency(F)	Fx
15	2	30
18	3	54
20	5	100
25	10	250
30	12	360
35	10	350
40	5	200
42	2	84
45	1	45
	Σf = 50	Σfx = 473

Arithmetic mean = Σfx/Σf

NOTES

Where,

Σfx = 473

Σf = 50

Arithmetic mean = 1473/50 = 29.46

Continuous series

4. Find arithmetic series for the following distribution.

Marks : 10–20 20–30 30–40 40–50 50–60 60–70 70–80 80–90

No. of students : 6 12 18 20 20 14 8 2

Marks	Frequency(f)	Mid value(X)	fx
10–20	6	15	90
20–30	12	25	300
30–40	18	35	630
40–50	20	45	900
50–60	20	55	1100
60–70	14	65	910
70–80	8	75	600
80–90	2	85	170
	Σf = 100		Σfx = 4700

Arithmetic mean = $\Sigma fx/\Sigma f$

Where,

Σfx = 4700

Σf = 100

Arithmetic mean = 4700/100

= 47

5. Calculate the range of the following distribution, showing income of 10 workers. Also calculate the co-efficient of range.

25 37 40 23 58 75 89 20 81 95

Range = H-L

H = Highest value = 95

L = Lowest value = 20

Range = 95 – 20 = 75

Coefficient of range = (H-L)/(H+L)

= (95-20)/(95+20)

= 75/115

= .6521

NOTES

6. Find the quartile deviation and its co-efficient.

   20 58 40 12 30 15 50

   First of all arrange the data in ascending order.

   12 15 20 28 30 40 50

Q1 = Size of (N+1)/4th item
= Size of (7+1)/4th item
= Size of (8/4)th item
= 2nd item
= 15

Q3 = Size of 3 × (N+1)4th item
= Size of 3 × (7+1)/4th item
= Size of 3 × 8/4th item
= (3×2)nd item
= 6th item
= 40

Co-efficient Deviation = (Q3 – Q1)/(Q3 + 1)
= (40 – 15)/(40 + 15)
= 25/55
= .4545

9.4 DESCRIPTIVE ANALYSIS OF BIVARIATE DATA

As already mentioned, bivariate analysis examines the relationship between two variables. There are various methods used for carrying out bivariate analysis. We will discuss two methods, namely, cross-tabulation and correlation coefficient.

(i) Cross-tabulation

In simple tabulation, the frequency and the percentage for each question was calculated. In cross-tabulation, responses to two questions are combined and data is tabulated together. A cross-tabulation counts the number of observations in each cross-category of two variables. The descriptive result of a cross-tabulation is a frequency count for each cell in the analysis. For example, in cross-tabulating a two-category measure of income (low- and high-income households) with a two-category measure of purchase intention of a product (low and high purchase intentions) the basic result is a cross-classification as shown in Table 9.8.

Table 9.8 Cross-table of Purchase Intention and Income

		Income	
		Low Income	**High Income**
Purchase Intention	Low purchase intention	120	60
	High purchase intention	80	190
		200	250

The results of cross-tabulation show the number of sample respondents with low income having low purchase intention, low income with high purchase intention, high income with low purchase intention and high income with high purchase intention.

As is the case with simple tabulations, the results of a cross-tabulation are more meaningful if cell frequencies are computed as percentages. The percentages can be computed in three-ways. As is the case of Table 9.8, the percentages can be computed (i) row-wise so that the percentages in each row add up to 100 per cent; (2) column-wise so that the percentages in each column add up to 100 per cent or (3) cell percentages, such that percentages added across all cells equal 100 per cent. The interpretation of percentages is different in each of the three cases. Therefore, the question arises which of these percentages is most useful to the researcher. What is the general rule for computing percentages?

The basis for calculating category percentage depends upon the nature of relationship between the variables. One of the variables could be viewed as dependent variable and the other one as independent variable. In the cross-tabulation presented in Table 9.8, the purchase intention could be treated as dependent variable, which depends upon income (independent variable). The rule is to cast percentages in the direction of independent (causal) variable across the dependent variable. For Table 9.8, there are 200 respondents with low income, out of which 120 have low purchase intention for the product. In terms of percentages, 60 per cent of the respondents with low income have low purchase intention for the product. Now there are 250 people with high income, out of which 60 have low purchase intention and 190 have high purchase intention for the product. By calculating percentages column wise, it is seen that 24 per cent have low purchase intention whereas 76 per cent have high purchase intention for the product. The results indicate that with increase in income, the purchase intention for the product increases.

Table 9.9 presents the percentages column-wise as given below:

Table 9.9 Cross-table of Purchase Intention and Income (Column-wise Percentages)

		Income	
		Low Income	**High Income**
Purchase Intention	Low purchase intention	60%	24%
	High purchase intention	40%	76%
		100%	100%

From the above example, it is clear that any two variables each having certain categories can be cross-tabulated. The interpretation of the cross-tabulation results may show a high association between two variables. That does not mean one of them, the independent variable, is the cause of the other variable—the dependent variable. Causality between the two variables is more of an assumptions made by the researcher based on his experience or expectations. Just because there is a high association between two variables, it does not imply a cause-and-effect relationship.

(ii) Correlation coefficient

Simple correlation measures the degree of association between two variables. The correlation could be positive, negative or zero.

Quantitative estimate of a linear correlation

A quantitative estimate of a linear correlation between two variables *X* and *Y* is given by Karl Pearson as:

$$r_{xy} = \frac{\sum_{i=1}^{n} (X_i - \overline{X})(Y_i - \overline{Y})}{\sqrt{\sum_{i=1}^{n} (X_i - \overline{X})^2} \sqrt{\sum_{i=1}^{n} (Y_i - \overline{Y})^2}}$$

which may be rewritten as:

$$r_{xy} = \frac{\sum_{i=1}^{n} X_i Y_i - n\overline{X}\ \overline{Y}}{\sqrt{\sum_{i=1}^{n} X_i^2 - n\overline{X}^2} \sqrt{\sum_{i=1}^{n} Y_i^2 - n\overline{Y}^2}}$$

Where, r_{xy} = Correlation coefficient between *X* and *Y*

$\overline{X}$ = Mean of the variable *X*

$\overline{Y}$ = Mean of the variable *Y*

n = Size of the sample

It may be noted that the above-mentioned formulae are for the linear correlation coefficient. The linear correlation coefficient takes a value between –1 and +1 (both values inclusive). If the value of the correlation coefficient is equal to 1, the two variables are perfectly positively correlated. Similarly, if the correlation coefficient between the two variables *X* and *Y* is –1, such a correlation is called perfect negative correlation. Let us consider an example to show the computation and interpretation of correlation coefficient.

Example 9.12: Consider the data on the quantity demanded and the price of a commodity over a ten-year period as given in the following table:

Year	Demand	Price
1996	100	5
1997	75	7
1998	80	6
1999	70	6
2000	50	8
2001	65	7
2002	90	5
2003	100	4
2004	110	3
2005	60	9

NOTES

Estimate the correlation coefficient between the quantity demanded and price and interpret the same.

Solution:

This problem will be attempted first by showing all the detailed computations using the following formula.

$$r_{xy} = \frac{\sum_{i=1}^{n} X_i Y_i - n\bar{X}\,\bar{Y}}{\sqrt{\sum_{i=1}^{n} X_i^2 - n\bar{X}^2}\sqrt{\sum_{i=1}^{n} Y_i^2 - n\bar{Y}^2}}$$

The required computations are shown in the following table:

Year	Demand (Y)	Price (X)	XY	X^2	Y^2
1996	100	5	500	25	10000
1997	75	7	525	49	5625
1998	80	6	480	36	6400
1999	70	6	420	36	4900
2000	50	8	400	64	2500
2001	65	7	455	49	4225
2002	90	5	450	25	8100
2003	100	4	400	16	10000
2004	110	3	330	9	12100
2005	60	9	540	81	3600
TOTAL	800	60	4500	390	67450

$\sum XY = 4500$ $\qquad$ $\sum X^2 = 390$

$\sum Y^2 = 67{,}450$ $\qquad$ $\sum Y = 800$

$\sum X = 60$ $\qquad$ $n = 10$

$$\bar{Y} = \frac{\sum Y}{n} = \frac{800}{10} = 80 \qquad \bar{X} = \frac{\sum X}{n} = \frac{60}{10} = 6$$

NOTES

Substituting these values in the formula for the correlation coefficient, we get:

$$r_{xy} = \frac{4500 - 10 \times 6 \times 80}{\sqrt{390 - 10 \times 6 \times 6}\ \sqrt{67450 - 64000}}$$

$$= \frac{4500 - 4800}{\sqrt{390 - 360}\ \sqrt{67450 - 64000}}$$

$$= \frac{-300}{\sqrt{30}\ \sqrt{3450}} = \frac{-300}{5.477 \times 58.737}$$

$$= \frac{-300}{321.701} = -0.9325$$

The value of the correlation coefficient between the quantity demanded and price is –0.9325, which is negative and very high. This shows that the quantity demanded and price move in the opposite directions.

Exercises

1. You are presented with the following table of frequency counts to show the nature of relationship between age and watching of movies in a cinema hall. What conclusion can be drawn?

Frequency of watching movies	Age	
	Under 35	35 & above
4 or more times in a month	200	80
Less than 4 times in a month	130	190
Total	330	270

2. The following bivariate table was prepared to understand the relationship between preference for continental food and monthly income of the respondents. What conclusion can be drawn?

		< ₹ 30,000	₹ 30,000 – ₹ 60,000	More than ₹ 60,000
Preference for continental food	Yes	20	32	17
	No	100	148	83
	Total	120	180	100

3. The table below presents the ranks which were assigned by three judges to the works of ten artists:

S. No.	1	2	3	4	5	6	7	8	9	10
Judge A	5	7	4	1	3	2	9	8	10	6
Judge B	4	8	3	2	7	1	10	6	9	5
Judge C	8	6	2	10	4	1	3	9	5	7

Compute the correlation coefficient for each pair of ranking and decide:

(a) Which two judges are most alike in their opinions about these artists?

(b) Which two judges are different in their opinions about their artists?

Check Your Progress

3. Which type of data can be computed through median?
4. State the positively skewed distribution.
5. Mention the limitation of range as a measure of dispersion.
6. What is the descriptive result of a cross-tabulation?

9.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Some of the common ways of summarizing data are by calculating average, range, standard deviation, frequency, and percentage distribution.
2. Inferential analysis is based on probability theory and a necessary condition for carrying out inferential analysis is that the sample should be drawn at random.
3. The median can be computed for ratio, interval or ordinal scale data.
4. The positively skewed distribution is mean > median > mode.
5. The limitation of range as a measure of dispersion is that it considers only the extreme value and ignores all other data points.
6. The descriptive result of a cross-tabulation is a frequency count for each cell in the analysis.

9.6 SUMMARY

- Data analysis could be univariate, bivariate and multivariate. Further, it could be descriptive or inferential.
- The type of analysis depends upon the level of measurement i.e. nominal, ordinal, interval and ratio.
- The bivariate analysis of data is illustrated through cross-table and correlation coefficient.

9.7 KEY WORDS

- **Bivariate analysis**: The data analysis that deals with analysis of two variables at a time.
- **Inferential analysis**: The data analysis that attempts to generalize the results of sample.
- **Median:** The value in the distribution such that 50 per cent of observations in the distribution are below it and 50 per cent are above it.
- **Mode:** The point of maximum frequency in a distribution.
- **Univariate analysis**: The data analysis that deals with the analysis of one variable at a time.

9.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Differentiate between descriptive and inferential analysis of data.
2. Briefly explain analysis of nominal scale data with multiple category responses.

Long-Answer Questions

1. Explain with the help of examples various measures of central tendency.
2. Discuss various measures of dispersions. List out their merits and demerits.
3. How does one go about preparing cross-table between two variables each having two categories? In what ways should percentages be calculated to interpret the results of a cross-tabulation?
4. You are presented with the following table of frequency counts to show the nature of relationship between age and watching of movies in a cinema hall. What conclusion can be drawn?

Frequency of watching movies	**Age**	
	Under 35	**35 & above**
4 or more times in a month	200	80
Less than 4 times in a month	130	190
Total	330	270

5. Compute the correlation coefficient between sales and advertising expenditure of a company from given data. Also interpret the results.

S. No.	1	2	3	4	5
Sales (` crore)	236	300	453	500	720
Advt. Exp. (` crore)	10	11	13	14	17

9.9 FURTHER READINGS

Chawla D and Sondhi N. 2016. *Research Methodology: Concepts and Cases*, 2nd edition. New Delhi: Vikas Publishing House.

Cooper, D R. 2006. *Business Research Methods*. New Delhi: Tata McGraw Hill Publishing Company Ltd.

Kinnear, T C and Taylor, J R. 1996. *Marketing Research: An Applied Approach,* 5th edn. New York: McGraw Hill, Inc.

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UNIT 10 TESTING OF HYPOTHESES

NOTES

Structure

10.0 INTRODUCTION

A hypothesis is an assumption or a statement that may or may not be true. The hypothesis is tested on the basis of information obtained from a sample. Instead of asking, for example, what the mean assessed value of an apartment in a multistoried building is, one may be interested in knowing whether or not the assessed value equals some particular value, say ₹80 lakh. Some other examples could be whether a new drug is more effective than the existing drug based on the sample data, and whether the proportion of smokers in a class is different from 0.30. The formulation of hypothesis has already been discussed in Unit 2. We will now study the concepts and steps in the testing of hypothesis exercise.

10.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the concepts used in the testing of hypothesis exercise
- Explain the steps used in testing of hypothesis exercise
- Explain the test of the significance of the mean of a single population using both *t* and *Z* test
- Explain the test of the significance of difference between two population means using *t* and *Z* tests

- Discuss the test of the significance of a single population proportion
- Explain the test of the significance of the difference between two population proportions using a Z test

10.2 CONCEPTS IN TESTING OF HYPOTHESIS

Below are discussed some concepts on testing of hypotheses to be used in this unit.

- **Null hypothesis:** The hypotheses that are proposed with the intent of receiving a rejection for them are called null hypotheses. This requires that we hypothesize the opposite of what is desired to be proved. For example, if we want to show that sales and advertisement expenditure are related, we formulate the null hypothesis that they are not related. If we want to prove that the average wages of skilled workers in town 1 is greater than that of town 2, we formulate the null hypotheses that there is no difference in the average wages of the skilled workers in both the towns. A null hypothesis is denoted by H_0.
- **Alternative hypotheses:** Rejection of null hypotheses leads to the acceptance of alternative hypotheses. The rejection of null hypothesis indicates that the relationship between variables (e.g., sales and advertisement expenditure) or the difference between means (e.g., wages of skilled workers in town 1 and town 2) or the difference between proportions have statistical significance and the acceptance of the null hypotheses indicates that these differences are due to chance. The alternative hypotheses are denoted by H_1.
- **One-tailed and two-tailed tests:** A test is called one-sided (or one-tailed) only if the null hypothesis gets rejected when a value of the test statistic falls in one specified tail of the distribution. Further, the test is called two-sided (or two-tailed) if null hypothesis gets rejected when a value of the test statistic falls in either one or the other of the two tails of its sampling distribution. For example, consider a soft drink bottling plant which dispenses soft drinks in bottles of 300 ml capacity. The bottling is done through an automatic plant. An overfilling of bottle (liquid content more than 300 ml) means a huge loss to the company given the large volume of sales. An underfilling means the customers are getting less than 300 ml of the drink when they are paying for 300 ml. This could bring bad reputation to the company. The company wants to avoid both overfilling and underfilling. Therefore, it would prefer to test the hypothesis whether the mean content of the bottles is different from 300 ml. This hypothesis could be written as:

$$H_0 \quad : \quad \mu = 300 \text{ ml.}$$
$$H_1 \quad : \quad \mu \neq 300 \text{ ml.}$$

The hypotheses stated above are called two-tailed or two-sided hypotheses.

However, if the concern is the overfilling of bottles, it could be stated as:

$H_0 \quad : \quad \mu = 300$ ml.

$H_1 \quad : \quad \mu > 300$ ml.

Such hypotheses are called one-tailed or one-sided hypotheses and the researcher would be interested in the upper tail (right hand tail) of the distribution. If however, the concern is loss of reputation of the company (underfilling of the bottles), the hypothesis may be stated as:

$H_0 \quad : \quad \mu = 300$ ml.

$H_1 \quad : \quad \mu < 300$ ml.

The hypothesis stated above is also called one-tailed test and the researcher would be interested in the lower tail (left hand tail) of the distribution.

Type I and type II error: The acceptance or rejection of a hypothesis is based upon sample results and there is always a possibility of sample not being representative of the population. This could result in errors, as a consequence of which inferences drawn could be wrong. The situation could be depicted as given in Figure 10.1.

	Accept H_0	Reject H_0
H_0 True	Correct decision	Type I Error
H_0 False	Type II Error	Correct decision

Fig. 10.1 *Type I and Type II Errors*

If null hypothesis H_0 is true and is accepted or H_0 when false is rejected, the decision is correct in either case. However, if the hypothesis H_0 is rejected when it is actually true, the researcher is committing what is called a Type I error. The probability of committing a Type I error is denoted by alpha (α). This is termed as the level of significance. Similarly, if the null hypothesis H_0 when false is accepted, the researcher is committing an error called Type II error. The probability of committing a Type II error is denoted by beta (β). The expression $1 - \beta$ is called power of test. To decrease the risk of committing both types of errors, you may increase the sample size.

10.2.1 Steps in Testing of Hypothesis Exercise

The following steps are followed in the testing of a hypothesis:

Setting up of a hypothesis: The first step is to establish the hypothesis to be tested. As it is known, these statistical hypotheses are generally assumptions about the value of the population parameter; the hypothesis specifies a single value or a range of values for two different hypotheses rather than constructing a single

hypothesis. These two hypotheses are generally referred to as (1) the null hypotheses denoted by H_0 and (2) alternative hypothesis denoted by H_1.

The null hypothesis is the hypothesis of the population parameter taking a specified value. In case of two populations, the null hypothesis is of no difference or the difference taking a specified value. The hypothesis that is different from the null hypothesis is the alternative hypothesis. If the null hypothesis H_0 is rejected based upon the sample information, the alternative hypothesis H_1 is accepted. Therefore, the two hypotheses are constructed in such a way that if one is true, the other one is false and vice versa.

Setting up of a suitable significance level: The next step is to choose a suitable level of significance. The level of significance denoted by α is chosen before drawing any sample. The level of significance denotes the probability of rejecting the null hypothesis when it is true. The value of α varies from problem to problem, but usually it is taken as either 5 per cent or 1 per cent. A 5 per cent level of significance means that there are 5 chances out of hundred that a null hypothesis will get rejected when it should be accepted. When the null hypothesis is rejected at any level of significance, the test result is said to be significant. Further, if a hypothesis is rejected at 1 per cent level, it must also be rejected at 5 per cent significance level.

Determination of a test statistic: The next step is to determine a suitable test statistic and its distribution. As would be seen later, the test statistic could be t, Z, χ^2 or F, depending upon various assumptions to be discussed later in the book.

Determination of critical region: Before a sample is drawn from the population, it is very important to specify the values of test statistic that will lead to rejection or acceptance of the null hypothesis. The one that leads to the rejection of null hypothesis is called the critical region. Given a level of significance, α, the optimal critical region for a two-tailed test consists of that $\alpha/2$ per cent area in the right hand tail of the distribution plus that $\alpha/2$ per cent in the left hand tail of the distribution where that null hypothesis is rejected.

Computing the value of test-statistic: The next step is to compute the value of the test statistic based upon a random sample of size n. Once the value of test statistic is computed, one needs to examine whether the sample results fall in the critical region or in the acceptance region.

Making decision: The hypothesis may be rejected or accepted depending upon whether the value of the test statistic falls in the rejection or the acceptance region. Management decisions are based upon the statistical decision of either rejecting or accepting the null hypothesis.

In case a hypothesis is rejected, the difference between the sample statistic and the hypothesized population parameter is considered to be significant. On the other hand, if the hypothesis is accepted, the difference between the sample statistic and the hypothesized population parameter is not regarded as significant and can be attributed to chance.

10.2.2 Test Statistic for Testing Hypothesis about Population Mean

In this section, we will take up the test of hypothesis about population mean in a case of single population.

NOTES

One of the important things that have to be kept in mind is the use of an appropriate test statistic. In case the sample size is large ($n > 30$), Z statistic would be used. For a small sample size ($n \leq 30$), a further question regarding the knowledge of population standard deviation (σ) is asked. If the population standard deviation σ is known, a Z statistic can be used. However, if σ is unknown and is estimated using sample data, a t test with appropriate degrees of freedom is used under the assumption that the sample is drawn from a normal population. It is assumed that you have the knowledge of Z and t distribution from the course on statistics. However, these would be briefly reviewed at the appropriate place. Table 10.1 summarizes the appropriateness of the test statistic for conducting a test of hypothesis regarding the population mean.

Table 10.1 *Appropriateness of Test Statistic in Testing Hypotheses about Means*

Sample Size	**Knowledge of Population Standard Deviation (σ)**	
	Known	**Not Known**
Large ($n > 30$)	Z	Z
Small ($n \leq 30$)	Z	t

Check Your Progress

1. What is a two-tailed test?
2. Mention the symbol through which the probability of committing a Type II error is denoted.
3. What is called as the critical region?

10.3 TESTS CONCERNING MEANS-THE CASE OF SINGLE POPULATION

In this section, a number of illustrations will be taken up to explain the test of hypothesis concerning mean. Two cases of large sample and small samples will be taken up.

Case of large sample

As mentioned earlier, in case the sample size n is large or small but the value of the population standard deviation is known, a Z test is appropriate. There can be alternate cases of two- tailed and one-tailed tests of hypotheses.

NOTES

Corresponding to the null hypothesis $H_0 : \mu = \mu_0$, the following criteria could be used as shown in Table 10.2.

The test statistic is given by,

$$Z = \frac{\bar{X} - \mu_{H0}}{\frac{\sigma}{\sqrt{n}}}$$

Where,

$\bar{X}$ = Sample mean

σ = Population standard deviation

μ_{H0} = The value of μ under the assumption that the null hypothesis is true.

n = Size of sample.

Table 10.2 Criteria for Accepting or Rejecting Null Hypothesis under Different Cases of Alternative Hypotheses

S. No.	Alternative Hypothesis	Reject the Null Hypothesis if	Accept the Null Hypothesis if
1.	$\mu < \mu_0$	$Z < -Z_\alpha$	$Z \geq -Z_\alpha$
2.	$\mu > \mu_0$	$Z > Z_\alpha$	$Z \leq Z_\alpha$
3.	$\mu \neq \mu_0$	$Z < -Z_{\alpha/2}$ or $Z > Z_{\alpha/2}$	$-Z_{\alpha/2} \leq Z \leq Z_{\alpha/2}$

If the population standard deviation σ is unknown, the sample standard deviation $s = \sqrt{\frac{1}{n-1}\sum(X - \bar{X})^2}$

is used as an estimate of σ. It may be noted that Z_α and $Z_{\alpha/2}$ are Z values such that the area to the right under the standard normal distribution is α and $\alpha/2$ respectively. Below are solved examples using the above concepts.

Example 10.1: A sample of 200 bulbs made by a company give a lifetime mean of 1540 hours with a standard deviation of 42 hours. Is it likely that the sample has been drawn from a population with a mean lifetime of 1500 hours? You may use 5 per cent level of significance.

Solution:

In the above example, the sample size is large ($n = 200$), sample mean ($\bar{X}$) equals 1540 hours and the sample standard deviation (s) is equal to 42 hours. The null and alternative hypotheses can be written as:

H_0 : $\mu = 1500$ hrs

H_1 : $\mu \neq 1500$ hrs

It is a two-tailed test with level of significance (α) to be equal to 0.05. Since n is large ($n > 30$), though population standard deviation σ is unknown, one can use Z test. The test statistics are given by:

$$Z = \frac{\bar{X} - \mu_{H0}}{\frac{\sigma}{X}}$$

Where, μ_{H0} = Value of μ under the assumption that the null hypothesis is true

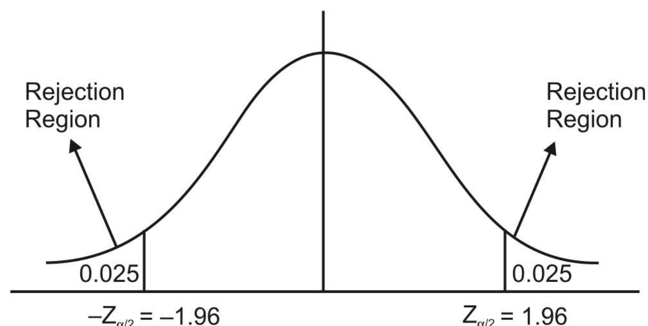
$\frac{\sigma}{X}$ = Estimated standard error of mean

$$\text{Here } \mu_{H0} = 1{,}500, \frac{\sigma}{X} = \frac{\hat{\sigma}}{\sqrt{n}} = \frac{s}{\sqrt{n}} = \frac{42}{\sqrt{200}} = 2.97$$

(Note that $\hat{\sigma}$ is estimated value of σ.)

$$Z = \frac{\bar{X} - \mu_{H0}}{\frac{s}{\sqrt{n}}} = \frac{1{,}540 - 1{,}500}{2.97} = \frac{40}{2.97} = 13.47$$

The value of $\alpha = 0.05$ and since it is a two-tailed test, the critical value Z is given by $-Z_{\alpha/2}$ and $Z_{\alpha/2}$ which could be obtained from the standard normal Table 7.1 given in Unit 7.



Rejection regions for Example 10.1

Since the computed value of $Z = 13.47$ lies in the rejection region, the null hypothesis is rejected. Therefore, it can be concluded that the average life of the bulb is significantly different from 1,500 hours.

Example 10.2: On a typing test, a random sample of 36 graduates of a secretarial school averaged 73.6 words with a standard deviation of 8.10 words per minute. Test an employer's claim that the school's graduates average less than 75.0 words per minute using the 5 per cent level of significance.

Solution:

H_0 : $\mu = 75$

H_1 : $\mu < 75$

NOTES

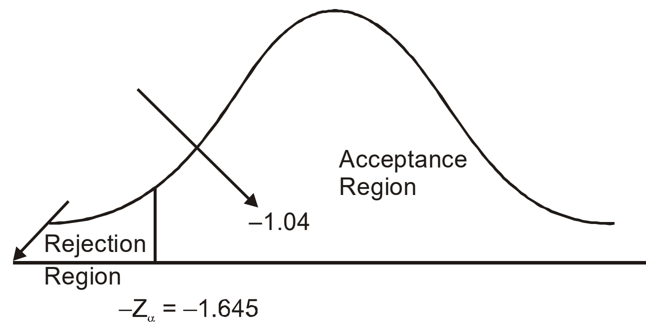
$\bar{X}$ = 73.6, s = 8.10, n = 36 and α = 0.05. As the sample size is large ($n > 30$), though population standard deviation σ is unknown, Z test is appropriate.

The test statistic is given by:

$$Z = \frac{\bar{X} - \mu_{H0}}{\hat{\sigma}_{\bar{x}}} = \frac{73.6 - 75}{1.35} = \frac{-1.4}{1.35} = -1.04$$

$$\left(\hat{\sigma}_{\bar{x}} = \frac{s}{\sqrt{n}} = \frac{8.10}{\sqrt{36}} = \frac{8.10}{6} = 1.35\right)$$

Since it is a one-tailed test and the interest is in the left hand tail of the distribution, the critical value of Z is given by $-Z_\alpha = -1.645$. Now, the computed value of Z lies in the acceptance region, and the null hypothesis is accepted as shown below:



Rejection region for Example 10.2

Case of small sample

In case the sample size is small ($n \leq 30$) and is drawn from a population having a normal population with unknown standard deviation σ, a t test is used to conduct the hypothesis for the test of mean. The t distribution is a symmetrical distribution just like the normal one. However, t distribution is higher at the tail and lower at the peak. The t distribution is flatter than the normal distribution. With an increase in the sample size (and hence degrees of freedom), t distribution loses its flatness and approaches the normal distribution whenever $n > 30$. A comparative shape of t and normal distribution is given in Figure 10.2.

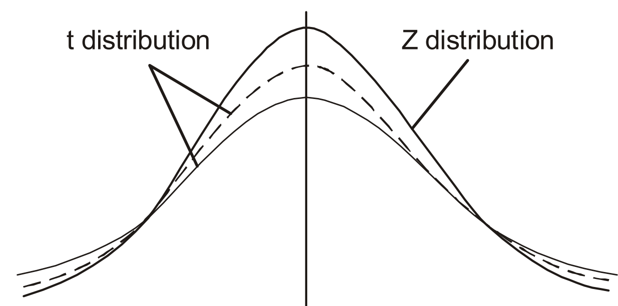


Fig. 10.2 *Shape of t and Normal Distribution*

NOTES

The procedure for testing the hypothesis of a mean is similar to what is explained in the case of large sample. The test statistic used in this case is:

$$t_{n-1} = \frac{\bar{X} - \mu_{H0}}{\hat{\sigma}_{\bar{x}}}$$

Where, $\hat{\sigma}_{\bar{x}} = \frac{s}{\sqrt{n}}$ (where s = Sample standard deviation)

$n - 1$ = degrees of freedom

A few examples pertaining to '*t*' test are worked out for testing the hypothesis of mean in case of a small sample.

Example 10.3: Prices of share (in ₹) of a company on the different days in a month were found to be 66, 65, 69, 70, 69, 71, 70, 63, 64 and 68. Examine whether the mean price of shares in the month is different from 65. You may use 10 per cent level of significance.

Solution:

$H_0 : \mu = 65$

$H_1 : \mu \neq 65$

Since the sample size is $n = 10$, which is small, and the sample standard deviation is unknown, the appropriate test in this case would be *t*. First of all, we need to estimate the value of sample mean ($\bar{X}$) and the sample standard deviation (*s*). It is known that the sample mean and the standard deviation are given by the following formula.

$$\bar{X} = \frac{\sum X}{n} \quad s = \sqrt{\frac{1}{n-1}\sum\left(X - \bar{X}\right)^2}$$

The computation of $\bar{X}$ and s is shown in Table 10.3.

$$\sum X = 675, \quad \bar{X} = \frac{\sum X}{n} = \frac{675}{10} = 67.5$$

$$\sum\left(X - \bar{X}\right)^2 = 70.5$$

$$s^2 = \frac{1}{n-1}\sum\left(X - \bar{X}\right)^2 \frac{70.5}{9} = 7.83$$

$$s = \sqrt{7.83} = 2.80$$

NOTES

Table 10.3 Computation of Sample Mean and Standard Deviation

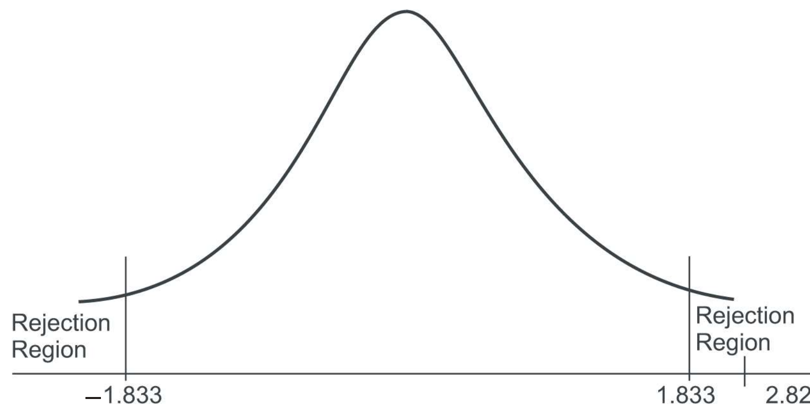
S. No.	X	$X - \overline{X}$	$(X - \overline{X})^2$
1	66	– 1.5	2.25
2	65	– 2.5	6.25
3	69	1.5	2.25
4	70	2.5	6.25
5	69	1.5	2.25
6	71	3.5	12.25
7	70	2.5	6.25
8	63	– 4.5	20.25
9	64	– 3.5	12.25
10	68	0.5	0.25
Total	675	0	70.5

The test statistic is given by:

$$t_{n-1} = \frac{\overline{X} - \mu_{H0}}{\frac{\hat{\sigma}}{x}} = \frac{\overline{X} - \mu_{H0}}{\frac{s}{\sqrt{n}}} = \frac{67.5 - 65}{\frac{2.8}{\sqrt{10}}} = \frac{2.5 \times \sqrt{10}}{2.8}$$

$$= 2.5 \times 3.16/2.8 = 7.91/2.8 = 2.82$$

The critical values of t with 9 degrees of freedom for a two-tailed test are given by –1.833 and 1.833. Since the computed value of t lies in the rejection region (see figure below), the null hypotheses is rejected.



Rejection regions for Example 10.3

Therefore, the average price of the share of the company is different from 65.

NOTES

Example 10.4: Past records indicate that a golfer has averaged 82 on a certain course. With a new set of clubs, he averages 7 over five rounds with a standard deviation of 2.65. Can we conclude that at 0.025 level of significance, the new club has an adverse effect on the performance?

Solution:

$H_0 \ : \ \mu = 82$

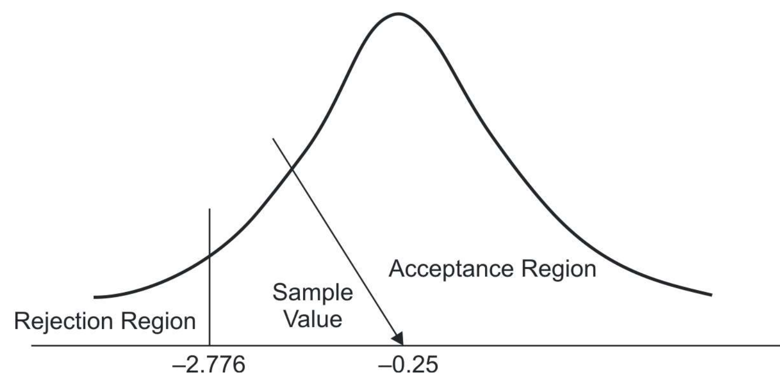
$H_1 \ : \ \mu < 82$

$\overline{X} = 7.9$, n = 5, s = 2.65, $\alpha = 0.025$. As the population standard deviation is unknown and the sample size is small ($n < 30$), a t test would be appropriate. The test statistic is given by:

$$t_{n-1} = \frac{\overline{X} - \mu_{H_0}}{\hat{\sigma}_{\overline{x}}} = \frac{\overline{X} - \mu_{H_0}}{s/\sqrt{n}} = \frac{7.9 - 8.2}{1.185} = \frac{-0.3}{1.185} = -0.25$$

$$\left(\hat{\sigma}_{\overline{x}} = \frac{s}{\sqrt{n}} = \frac{2.65}{\sqrt{5}} = 1.185\right)$$

The critical value of t at 0.025 level of significance with four degrees of freedom is given by $-t_\alpha = -2.776$ (see Table 10.4). As the sample t value of -0.25 lies in the acceptance region, the null hypothesis is accepted (see figure below).



Rejection region for Example 10.4

Therefore, there is no adverse effect on the performance due to a change in the club and the performance can be attributed to chance.

Table 10.4 *Some critical values of 't'*

Degrees of Freedom	Level of Significance		
	1%	5%	10%
1	63.657	12.706	6.314
2	9.925	4.303	2.920
3	5.841	3.182	2.353
4	4.604	2.776	2.132
5	4.032	2.571	2.015
6	3.707	2.447	1.943
7	3.499	2.365	1.895
8	3.355	2.306	1.860
9	3.250	2.262	1.833
10	3.169	2.228	1.812
11	3.106	2.201	1.796
12	3.055	2.179	1.782
13	3.012	2.160	1.771
14	2.977	2.145	1.761
15	2.947	2.131	1.753
16	2.921	2.120	1.746
17	2.898	2.110	1.740
18	2.878	2.101	1.734
19	2.861	2.093	1.729
20	2.845	2.086	1.725
21	2.831	2.080	1.721
22	2.819	2.074	1.717
23	2.807	2.069	1.714
24	2.797	2.064	1.711
25	2.787	2.060	1.708
26	2.779	2.056	1.706
27	2.771	2.052	1.703
28	2.763	2.048	1.701
29	2.756	2.045	1.699
α	2.576	1.960	1.645

NOTES

Note: These table values of '*t*' are in respect of two-tailed tests. If we use the *t*-distribution for one-tailed test then we are interested in determining the area located in one tail. So to find the appropriate *t*-value for a one-tailed test say at a 5% level with 12 degrees of freedom, then we should look in the above table under the 10% column opposite the 12 degrees of freedom row. (This value will be 1.782). This is true because the 10% column represents 10% of the area under the curve contained in both tails combined, and so it also represents 5% of the area under the curve contained in each of the tails separately.

10.4 TESTS FOR DIFFERENCE BETWEEN TWO POPULATION MEANS

So far, we have been concerned with the testing of means of a single population. We took up the cases of both large and small samples. It would be interesting to

examine the difference between the two population means. Again, various cases would be examined as discussed below:

Case of large sample

In case both the sample sizes are greater than 30, a *Z* test is used. The hypothesis to be tested may be written as:

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Where,

μ_1 = mean of population 1

μ_2 = mean of population 2

The above is a case of two-tailed test. The test statistic used is:

$$Z = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

$\overline{X}_1$ = Mean of sample drawn from population 1

$\overline{X}_2$ = Mean of sample drawn from population 2

n_1 = size of sample drawn from population 1

n_2 = size of sample drawn from population 2

If σ_1 and σ_2 are unknown, their estimates given by $\hat{\sigma}_1$ and $\hat{\sigma}_2$ are used.

$$\hat{\sigma}_1 = s_1 = \sqrt{\frac{1}{n_{1-1}} \sum_{i=1}^{n_1} (X_{1i} - \overline{X}_1)^2}$$

$$\hat{\sigma}_2 = s_2 = \sqrt{\frac{1}{n_{2-1}} \sum_{i=1}^{n_2} (X_{2i} - \overline{X}_2)^2}$$

The *Z* value for the problem can be computed using the above formula and compared with the table value to either accept or reject the hypothesis. Let us consider the following problem:

Example 10.5: A study is carried out to examine whether the mean hourly wages of the unskilled workers in the two cities—Ambala Cantt and Lucknow are the same. The random sample of hourly earnings in both the cities is taken and the results are presented in the Table 10.5.

Table 10.5 Survey Data on Hourly Earnings in Two Cities

City	Sample Mean Hourly Earnings	Standard Deviation of Sample	Sample Size
Ambala Cantt	₹ 8.95 ($\bar{x}_1$)	0.40 (s_1)	200 (n_1)
Lucknow	₹ 9.10 ($\bar{x}_2$)	0.60 (s_2)	175 (n_2)

NOTES

Using a 5 per cent level of significance, test the hypothesis of no difference in the average wages of unskilled workers in the two cities.

Solution: We use subscripts 1 and 2 for Ambala Cantt and Lucknow respectively.

$H_0 : \mu_1 = \mu_2 \rightarrow \mu_1 - \mu_2 = 0$

$H_1 : \mu_1 \neq \mu_2 \rightarrow \mu_1 - \mu_2 \neq 0$

The following survey data is given:

$\overline{X}_1 = 8.95, \overline{X}_2 = 9.10, s_1 = 0.40, s_2 = 0.60, n_1 = 200, n_2 = 175, \alpha = 0.05$

Since both n_1, n_2 are greater than 30 and the sample standard deviations are given, a Z test would be appropriate.

The test statistic is given by:

$$Z = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

As σ_1, σ_2 are unknown, their estimates would be used.

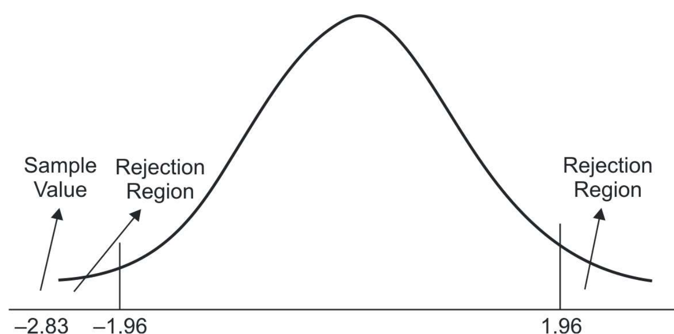
$$s_1 = \hat{\sigma}_1, \quad s_2 = \hat{\sigma}_2$$

$$\sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2}} = \sqrt{\frac{(0.4)^2}{200} + \frac{(0.6)^2}{175}} = \sqrt{0.0028} = 0.0053$$

$$Z = \frac{(8.95 - 9.10) - 0}{0.053} = -2.83$$

As the problem is of a two-tailed test, the critical values of Z at 5 per cent level of significance are given by $-Z_{\alpha/2} = -1.96$ and $Z_{\alpha/2} = 1.96$. The sample value of $Z = -2.83$ lies in the rejection region as shown in the figure below:

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Rejection regions for Example 10.5

Case of small sample

If the size of both the samples is less than 30 and the population standard deviation is unknown, the procedure described above to discuss the equality of two population means is not applicable in the sense that a t test would be applicable under the assumptions:

(a) Two population variances are equal.

(b) Two population variances are not equal.

Population variances are equal

If the two population variances are equal, it implies that their respective unbiased estimates are also equal. In such a case, the expression becomes:

$$\sqrt{\frac{\hat{\sigma}_1^2}{n_1}+\frac{\hat{\sigma}_2^2}{n_2}} = \sqrt{\frac{\hat{\sigma}^2}{n_1}+\frac{\hat{\sigma}^2}{n_2}} = \hat{\sigma}\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$$

(Assuming $\hat{\sigma}_1^2 = \hat{\sigma}_2^2 = \hat{\sigma}^2$)

To get an estimate of $\hat{\sigma}^2$, a weighted average of s_1^2 and s_2^2 is used, where the weights are the number of degrees of freedom of each sample. The weighted average is called a 'pooled estimate' of $\hat{\sigma}^2$. This pooled estimate is given by the expression:

$$\hat{\sigma}^2 = \frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}$$

The testing procedure could be explained as under:

$H_0 : \mu_1 = \mu_2 \quad \rightarrow \quad \mu_1 - \mu_2 = 0$

$H_1 : \mu_1 \neq \mu_2 \quad \rightarrow \quad \mu_1 - \mu_2 \neq 0$

NOTES

In this case, the test statistic t is given by the expression:

$$t_{n_1+n_2-2} = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\hat{\sigma}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where,

$$\hat{\sigma} = \sqrt{\frac{(n_1 - 1)s_1^2 + (\mu_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

Once the value of t statistic is computed from the sample data, it is compared with the tabulated value at a level of significance α to arrive at a decision regarding the acceptance or rejection of hypothesis. Let us work out a problem illustrating the concepts defined above.

Example 10.6: Two drugs meant to provide relief to arthritis sufferers were produced in two different laboratories. The first drug was administered to a group of 12 patients and produced an average of 8.5 hours of relief with a standard deviation of 1.8 hours. The second drug was tested on a sample of 8 patients and produced an average of 7.9 hours of relief with a standard deviation of 2.1 hours. Test the hypothesis that the first drug provides a significantly higher period of relief. You may use 5 per cent level of significance.

Solution: Let the subscripts 1 and 2 refer to drug 1 and drug 2 respectively.

$H_0 : \mu_1 = \mu_2 \quad \rightarrow \quad \mu_1 - \mu_2 = 0$

$H_1 : \mu_1 \neq \mu_2 \quad \rightarrow \quad \mu_1 - \mu_2 \neq 0$

The following survey data is given:

$$\overline{X}_1 = 8.5, \overline{X}_2 = 7.9, s_1 = 1.8, s_2 = 2.1, n_1 = 12, n_2 = 8$$

As both n_1, n_2 are small and the sample standard deviations are unknown, one may use a t test with the degrees of freedom $= n_1 + n_2 - 2 = 12 + 8 - 2 = 18$ d.f.

The test statistics is given by:

$$t_{n_1+n_2-2} = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\hat{\sigma}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

NOTES

Where,

$$\hat{\sigma} = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

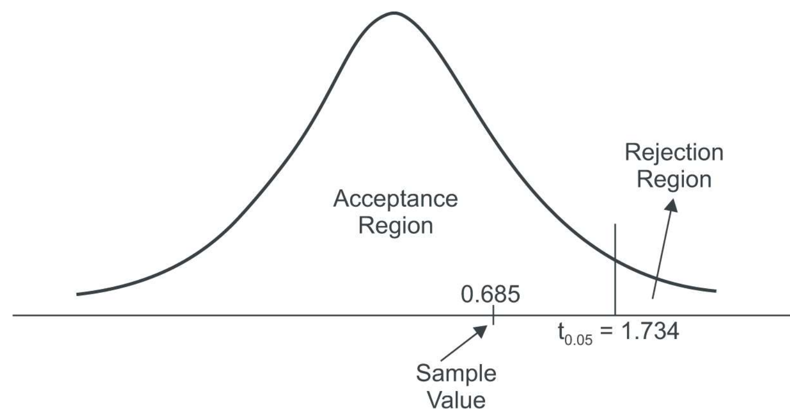
$$= \sqrt{\frac{(12-1)(1.8)^2 + (8-1)(2.1)^2}{12+8-2}} = \sqrt{\frac{11 \times 3.24 + 7 \times (4.41)}{18}}$$

$$= \sqrt{\frac{35.64 + 30.87}{18}} = \sqrt{\frac{66.61}{18}} = \sqrt{3.698} = 1.92$$

$$t_{18} = \frac{(8.5 - 7.9) - (0)}{1.92\sqrt{\frac{1}{12} + \frac{1}{8}}} = \frac{0.6}{1.92\sqrt{0.2083}}$$

$$= \frac{0.6}{1.92 \times 0.456} = \frac{0.6}{0.8755} = 0.685$$

The critical value of t with 18 degrees of freedom at 5 per cent level of significance is given by 1.734. The sample value of $t = 0.685$ lies in the acceptance region as shown in figure below:



Rejection region for Example 10.6

Therefore, the null hypothesis is accepted as there is not enough evidence to reject it. Therefore, one may conclude that the first drug is not significantly more effective than the second drug.

When population variances are not equal

In case population variances are not equal, the test statistic for testing the equality of two population means when the size of samples are small is given by:

$$t = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2}}}$$

NOTES

The degrees of freedom in such a case is given by the expression:

$$d.f = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1}\left(\frac{s_1^2}{n_1}\right)^2 + \frac{1}{n_2 - 1}\left(\frac{s_2^2}{n_2}\right)^2}$$

The procedure for testing of hypothesis remains the same as was discussed when the variances of two populations were assumed to be same. Let us consider an example to illustrate the same.

Example 10.7: There were two types of drugs (1 and 2) that were tried on some patients for reducing weight. There were 8 adults who were subjected to drug 1 and seven adults who were administered drug 2. The decrease in weight (in pounds) is given below:

Drug 1	10	8	12	14	7	15	13	11
Drug 2	12	10	7	6	12	11	12	

Do the drugs differ significantly in their effect on decreasing weight? You may use 5 per cent level of significance. Assume that the variances of two populations are not same.

Solution:

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Let us compute the sample means and standard deviations of the two samples as shown in Table 10.6.

Table 10.6 *Intermediate computations for sample means and standard deviations*

S.No.	X_1	X_2	$(X_1 - \bar{X}_1)$	$(X_2 - \bar{X}_2)$	$(X_1 - \bar{X}_1)^2$	$(X_2 - \bar{X}_2)^2$
1	10	12	–1.25	2	1.5625	4
2	8	10	–3.25	0	10.5625	0
3	12	7	0.75	-3	0.5625	9
4	14	6	2.75	-4	7.5625	16
5	7	12	–4.25	2	18.0625	4
6	15	11	3.75	1	14.0625	1
7	13	12	1.75	2	3.0625	4
8	11		–0.25		0.0625	
Total	90	70	0	0	55.5	38
Mean	11.25	10				

NOTES

$n_1 = 8,$ $\qquad n_2 = 7,$

$$\overline{X}_1 = \frac{\sum X_1}{n_1} = \frac{90}{8} = 11.25 \qquad \overline{X}_2 = \frac{\sum X_2}{n_2} = \frac{70}{7} = 10$$

$$s_1^2 = \frac{\Sigma(X_1 - \overline{X}_1)^2}{n_1 - 1} = \frac{55.5}{7} = 7.93$$

$$s_2^2 = \frac{\Sigma(X_2 - \overline{X}_2)^2}{n_2 - 1} = \frac{38}{6} = 6.33$$

$$\hat{\sigma}_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} = \sqrt{\frac{7.93}{8} + \frac{6.33}{7}} = \sqrt{0.99 + 0.90} = \sqrt{1.89} = 1.37$$

$$d.f. = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1}\left(\frac{s_1^2}{n_1}\right) + \frac{1}{n_2 - 1}\left(\frac{s_2^2}{n_2}\right)} = \frac{\left(\frac{7.33}{8} + \frac{6.33}{7}\right)^2}{\frac{1}{7}\left(\frac{7.33}{8}\right)^2 + \frac{1}{6}\left(\frac{6.33}{7}\right)^2}$$

$$= \frac{3.314}{0.12 + 0.136} = \frac{3.314}{0.12 + 0.136} = 12.996 = 13 \text{ (approx.)}$$

$$t = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2}}}$$

$$t = \frac{11.25 - 10}{1.37} = \frac{1.25}{1.37} = 0.912$$

The table value (critical value) of t with 13 degrees of freedom at 5 per cent level of significance is given by 2.16. As computed t is less than tabulated t, there is not enough evidence to reject H_o.

Check Your Progress

4. Which type of test is used in cases where the sample size is small ($n \leq 30$) and is drawn from a population having a normal population with unknown standard deviation ó to conduct the hypothesis for the test of mean?
5. How is the degrees of freedom in the two sample t test for testing the equality of means given?

10.5 TESTS CONCERNING POPULATION PROPORTION-THE CASE OF SINGLE POPULATION

We have already discussed the tests concerning population means. In the tests about proportion, one is interested in examining whether the respondents possess a particular attribute or not.

The random variable in such a case is a binary one in the sense it takes only two values—yes or no. As we know that either a student is a smoker or not, a consumer either uses a particular brand of product or not and lastly, a skilled worker may be either satisfied or not with the present job. At this stage it may be recalled that the binomial distribution is a theoretically correct distribution to use while dealing with proportions. Further, as the sample size increases, the binomial distribution approaches the normal distribution in characteristic. To be specific, whenever both np and nq (where n = number of trials, p = probability of success and q = probability of failure) are at least 5, one can use the normal distribution as a substitute for the binomial distribution.

The case of single population proportion

Suppose we want to test the hypotheses,

$H_0 \;:\; p = p_0$

$H_1 \;:\; p \neq p_0$

For large sample, the appropriate test statistic would be:

$$Z = \frac{\bar{p} - p_{H_0}}{\sigma_{\bar{p}}}$$

Where,

$\bar{p}$ = sample proportion

p_{H_0} = the value of p under the assumption that null hypothesis is true

$\sigma_{\bar{p}}$ = Standard error of sample proportion

The value of $\sigma_{\bar{p}}$ is computed by using the following formula:

$$\sigma_{\bar{p}} = \frac{\sqrt{p_{H_0} q_{H_0}}}{n}$$

Where, $q_{H_0} = 1 - p_{H_0}$

n = Sample size

For a given level of significance α, the computed value of Z is compared with the corresponding critical values, i.e. $Z_{\alpha/2}$ or $-Z_{\alpha/2}$ to accept or reject the null

NOTES

hypothesis. We will consider a few examples to explain the testing procedure for a single population proportion.

Example 10.8: An officer of the health department claims that 60 per cent of the male population of a village comprises smokers. A random sample of 50 males showed that 35 of them were smokers. Are these sample results consistent with the claim of the health officer? Use a level of significance of 0.05.

Solution:

Sample size (n) = 50

Sample proportion = $\bar{p} = \frac{x}{n} = \frac{35}{50} = 0.70$

H_0 : p = 0.60

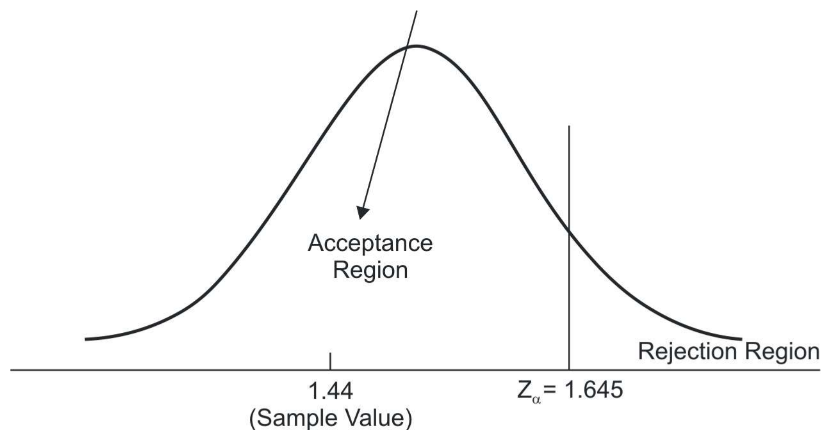
H_1 : p > 0.60

The test statistic is given by:

$$Z = \frac{\bar{p} - p_{H_0}}{\sigma_{\bar{p}}} = \frac{0.70 - 0.60}{0.069} = \frac{0.10}{0.069} = 1.44$$

$$\left(\sigma_{\bar{p}} = \sqrt{\frac{P_{H_0} q_{H_0}}{n}} = \sqrt{\frac{0.6 \times 0.4}{50}} = \sqrt{\frac{0.24}{50}} = 0.069\right)$$

It is a one-tailed test. For a given level of significance $\alpha = 0.05$, the critical value of Z is given by $Z_\alpha = Z_{0.05} = 1.645$. It is seen that the sample value of $Z = 1.44$ lies in the acceptance region as shown below (see figure).



Rejection region for Example 10.8

Therefore, there is not enough evidence to reject the null hypothesis. So it can be concluded that the proportion of male smokers is not statistically different from 0.60.

NOTES

10.6 TESTS FOR DIFFERENCE BETWEEN TWO POPULATION PROPORTIONS

Here, the interest is to test whether the two population proportions are equal or not. The hypothesis under investigation is:

$H_0 : p_1 = p_2 \quad \rightarrow p_1 - p_2 = 0$

$H_1 : p_1 \neq p_2 \quad \rightarrow p_1 - p_2 \neq 0$

The alternative hypothesis assumed is two sided. It could as well have been one sided. The test statistic is given by:

$$Z = \frac{\bar{p}_1 - \bar{p}_2 - (p_1 - p_2)H_0}{\sigma_{\bar{P}_1 - \bar{P}_2}}$$

Where,

$\bar{p}_1$ = Sample proportion possessing a particular attribute from population 1

$\bar{p}_2$ = Sample proportion possessing a particular attribute from population 2

$\sigma_{\bar{P}_1 - \bar{P}_2}$ = Standard error of difference between proportions.

$(p_1 - p_2)_{H0}$ = Value of difference between population proportion under the assumption that the null hypothesis is true.

The formula for $\sigma_{\bar{P}_1 - \bar{P}_2}$ is given by:

$$\sigma_{\bar{P}_1 - \bar{P}_2} = \sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}$$

We do not know the value of p_1, p_2, etc., but under the null hypothesis $p_1 = p_2 = p$.

$$\sigma_{\bar{P}_1 - \bar{P}_2} = \sqrt{\frac{pq}{n_1} + \frac{pq}{n_2}} = \sqrt{pq\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

The best estimate of p is given by:

$$\hat{p} = \frac{x_1 + x_2}{n_1 + n_2}$$

NOTES

Where,

x_1 = Number of successes in sample 1

x_2 = Number of successes in sample 2

n_1 = Size of sample taken from population 1

n_2 = Size of sample taken from population 2

It is known that $\bar{p}_1 = \frac{x_1}{n_1}$ and $\bar{p}_2 = \frac{x_2}{n_2}$.

Therefore, $x_1 = n_1 \bar{p}_1$ and $x_2 = n_2 \bar{p}_2$

Therefore, $\hat{p} = \frac{n_1 \bar{p}_1 + n_2 \bar{p}_2}{n_1 + n_2}$

Therefore, the estimate of standard error of difference between the two proportions is given by:

$$\hat{\sigma}_{\bar{P}_1 - \bar{P}_2} = \sqrt{\hat{p}\hat{q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

Where $\hat{p}$ is as defined above and $\hat{q} = 1 - \hat{p}$. Now, the test statistic may be rewritten as:

$$Z = \frac{\bar{p}_1 - \bar{p}_2 - (p_1 - p_2)H_0}{\sqrt{\hat{p}\hat{q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Now, for a given level of significance α, the sample Z value is compared with the critical Z value to accept or reject the null hypothesis. We consider below a few examples to illustrate the testing procedure described above.

Example 10.9: A company is interested in considering two different television advertisements for the promotion of a new product. The management believes that advertisement A is more effective than advertisement B. Two test market areas with virtually identical consumer characteristics are selected. Advertisement A is used in one area and advertisement B in the other area. In a random sample of 60 consumers who saw advertisement A, 18 tried the product. In a random sample of 100 customers who saw advertisement B, 22 tried the product. Does this indicate that advertisement A is more effective than advertisement B, if a 5 per cent level of significance is used?

Solution:

$H_0 : p_a = p_b$

$H_1 : p_a > p_b$

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$n_A = 60, \quad x_A = 18, \quad n_B = 100, \quad x_B = 22$

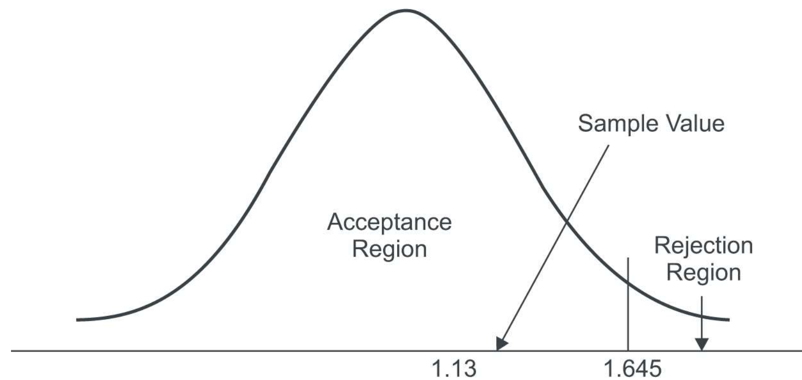
$$\left(\bar{p}_A = \frac{x_A}{n_A} = \frac{18}{60} = 0.3\right) \qquad \left(\bar{p}_B = \frac{x_B}{n_B} = \frac{22}{100} = 0.22\right)$$

$$Z = \frac{\bar{P}_A - \bar{P}_B - (p_A - p_B)H_0}{\sigma_{\bar{P}_A - \bar{P}_B}} = \frac{0.3 - 0.22 - 0}{\sqrt{\hat{p}\hat{q}\left(\frac{1}{n_A} + \frac{1}{n_B}\right)}}$$

$$= \frac{0.08}{\sqrt{0.25 \times 0.75\left(\frac{1}{60} + \frac{1}{100}\right)}} = \frac{0.08}{\sqrt{0.25 \times 0.75(0.0267)}} = \frac{0.08}{0.071} = 1.3$$

$$\left(\hat{p} = \frac{x_A + x_B}{n_A + n_B} = \frac{18 + 22}{60 + 100} = \frac{40}{160} = 0.25\right)$$

The critical value of Z at 5 per cent level of significance is 1.645. The sample value of $Z = 1.13$ lies in the acceptance region as shown in the figure below:



Rejection region for Example 10.9

Exercises

1. The company XYZ manufacturing bulbs hypothesizes that the life of its bulbs is 145 hours with a known standard deviation of 210 hours. A random sample of 25 bulbs gave a mean life of 130 hours. Using a 0.05 level of significance, can the company conclude that the mean life of bulbs is less than the 145 hours?
2. The manager of a hotel is trying to decide which of the two supposedly equally good cigarette–vending machines to install, tests each machine 500 times, and finds that machine I fails to work (neither delivers the cigarettes nor returns the money) 26 times and machine II fails to work 12 times. Using a 0.05 level of significance, can he conclude that two machines are not equally good?
3. If 54 out of a random sample of 150 boys smoke, while 31 out of random sample of 100 girls smoke, can we conclude at the 0.05 level of significance that the proportion of male smokers is higher than that of female smokers?

NOTES

4. Advertisements claim the average nicotine content of a certain kind of cigarette is 0.30 mg. Suspecting that this figure is too low, a consumer protection service takes a random sample of 15 of these cigarettes from different production lots and finds that their nicotine content has a mean of 0.33 mg with a standard deviation of 0.018 mg. Use the 0.05 level of significance to test the null hypothesis $\mu = 0.30$ against the alternative hypothesis $\mu > 30$.
5. In a study of the effectiveness of physical exercise in weight reduction, a group of 11 persons engaged in a prescribed programme of physical exercise for 45 days showed the following results:

S.No.	Weight before (pounds)	Weight after (pounds)	S.No.	Weight before (Pounds)	Weight after (Pounds)
1	209	196	7	158	159
2	178	171	8	180	180
3	169	170	9	170	164
4	212	207	10	153	152
5	180	177	11	183	179
6	192	190			

Use the 0.05 level of significance to test the null hypothesis that the prescribed programme of exercise is not effective in reducing weight.

6. In a departmental store's study designed to test whether the mean balance outstanding on 30-day charge account is same in its two suburban branch stores, random samples yielded the following results:

$n_1 = 60$ $\quad \bar{X}_1 = ₹\ 6420$ $\quad s_1 = ₹\ 1600$

$n_2 = 100$ $\quad \bar{X}_2 = ₹\ 7141$ $\quad s_2 = ₹\ 2213$

where the subscripts denote branch store 1 and branch store 2. Use the 0.05 level of significance to test the hypothesis against a suitable alternative.

7. A product is produced in two ways. A pilot test on 6^{th} times from each method indicates that product of method 1 has sample mean tensile strength 106 lbs and a standard deviation 12 lbs, whereas in method 2 the corresponding values of mean and standard deviation are 100 lbs and 10 lbs respectively. Greater tensile strength in the product is preferable. Use an appropriate large sample test of 5 per cent level of significance to test whether or not method 1 is better for processing the product. State clearly the null hypothesis.
8. 500 units from a factory are inspected and 12 are found to be defective; 800 units from another factory are inspected and 12 are found to be defective. Can it be concluded at 5 per cent level of significance that the production at the second factory is better than at the first factory?

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9. Two types of new cars produced in India are tested for petrol mileage. One group consisting of 36 cars averaged 14 km per litre while the other group consisting of 72 cars averaged 12.5 km per litre.

   (a) What test statistic is appropriate if $\sigma_1^2 = 1.5$ & $\sigma_2^2 = 2.0$?

   (b) Test, whether there exists a significant difference in the petrol consumption of two types of cars (use $\alpha = 0.01$).

10. Intelligence tests on two groups of boys and girls gave the following results:

Gender	Mean	Standard Deviation	Sample Size
Girls	75	15	150
Boys	70	20	250

Is there a difference in the mean scores obtained by the boys and girls? Let the level of significance be 5 per cent.

Check Your Progress

6. What are the least values of np and nq for which normal distribution can be used as a substitute for the binomial distribution?
7. State the assumption under which the estimate of standard error of difference between two sample proportion is obtained.

10.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. A test is called two-sided (or two -tailed) if null hypothesis gets rejected when a value of the test statistics falls in either one or the other of the two tails of its sampling distribution.
2. The probability of committing a Type II error is denoted by beta (β).
3. Before a sample is drawn from the population, it is very important to specify the values of test statistic that will lead to rejection or acceptance of the null hypothesis. The one that leads to the rejection of null hypothesis is called the critical region.
4. In case the sample size is small ($n \leq 30$) and is drawn from a population having a normal population with unknown standard deviation ó, a t test is used to conduct the hypothesis for the test of mean.
5. The degrees of freedom in the two sample t test for testing the equality of means is given by $n_1 + n_2 - 2$.
6. Whenever both np and nq (where n = number of trials, p = probability of success and q = probability of failure) are at least 5, one can us the normal distribution as a substitute for the binomial distribution.

7. The estimate of standard error of difference between two sample proportion is obtained under the assumption that null hypothesis is true.

NOTES

10.8 SUMMARY

- A hypothesis is a statement or an assumption regarding a population, which may or may not be true.
- The sequences of steps that need to be followed for the testing of hypothesis are: setting up of a hypothesis, setting up of a suitable significance level, determination of a test statistic, determination of critical region, computing the value of test-statistic and making decision
- In the test procedure for a single population mean or for examining the equality of two population means, for large samples, a *Z* test is appropriate whereas for the small samples, a *t* test is used under the two cases where: (i) population variances are equal and (ii) population variances are not equal.
- In the testing procedures concerning the proportion of a single population and the difference between two population proportions the hypotheses concerning them are carried out using a *Z* test under the assumption that the normal distribution could be used as an approximation to the binomial distribution for a large sample.

10.9 KEY WORDS

- **Critical region:** The region that leads to rejection of null hypothesis.
- **Level of significance:** The probability of committing a Type 1 error.
- **Null hypothesis:** The hypotheses that is proposed with the intent of receiving a rejection for them.
- **Type I error:** This occurs when null hypothesis is rejected when it is actually true.

10.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is alternative hypothesis?
2. Write a short note on one-tailed and two-tailed tests.
3. Briefly explain Type I and Type II error.

Long-Answer Questions

NOTES

1. Explain the various steps involved in the tests of hypothesis exercise.
2. Indicate whether a Z or t distribution is applicable in each of the following cases while conducting test for population mean.
   (i) $n = 31 \quad s = 12$
   (ii) $n = 15 \quad s = 9$
   (iii) $n = 64 \quad s = 8$
   (iv) $n = 28 \quad \sigma = 10$
   (v) $n = 56 \quad \sigma = 6$
3. The company XYZ manufacturing bulbs hypothesizes that the life of its bulbs is 145 hours with a known standard deviation of 210 hours. A random sample of 25 bulbs gave a mean life of 130 hours. Using a 0.05 level of significance, can the company conclude that the mean life of bulbs is less than the 145 hours?
4. Average annual income of the employees of a company has been reported to be ₹18,750. A random sample of 100 employees was taken. Then average annual income was found to be ₹19,240 with a standard deviation of ₹2,610. Test at 5 per cent level of significance whether the sample results are representative of population results.
5. If 54 out of a random sample of 150 boys smoke, while 31 out of random sample of 100 girls smoke, can we conclude at the 0.05 level of significance that the proportion of male smokers is higher than that of female smokers? Use the 0.05 level of significance to test the null hypothesis that the prescribed programme of exercise is not effective in reducing weight.
6. In a departmental store's study designed to test whether the mean balance outstanding on 30-day charge account is same in its two suburban branch stores, random samples yielded the following results:

   $n_1 = 60 \quad \overline{X}_1 = ₹6420 \quad s_1 = ₹1600$

   $n_2 = 100 \quad \overline{X}_2 = ₹7141 \quad s_2 = ₹2213$

   where the subscripts denote branch store 1 and branch store 2. Use the 0.05 level of significance to test the hypothesis against a suitable alternative.

10.11 FURTHER READINGS

NOTES

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BLOCK - IV
RESEARCH REPORT

NOTES

UNIT 11 CHI-SQUARE ANALYSIS

Structure

11.0 INTRODUCTION

In the last unit, we discussed the *Z* test for the equality of two population proportions. Now, in case we have more than two populations and want to test the equality of all of them simultaneously, it is not possible to do it using *Z* test. This is because *Z* test can examine the equality of two proportions at a time. In such a situation, the chi-square test can come to our rescue and can carry out the test in one go.

The chi-square test is widely used in research. For the use of chi-square test, data is required in the form of frequencies. Data expressed in percentages or proportion can also be used, provided it could be converted into frequencies. The majority of the applications of chi-square (χ^2) are with discrete data. The test could also be applied to continuous data, provided it is reduced to certain categories and tabulated in such a way that the chi-square may be applied.

Some of the important properties of the chi-square distribution are:

- Unlike the normal and t distribution, the chi-square distribution is not symmetric.
- The values of a chi-square are greater than or equal to zero.
- The shape of a chi-square distribution depends upon the degrees of freedom. With the increase in degrees of freedom, the distribution tends to normal.

There are many applications of a chi-square test. Some of them mentioned below will be discussed in this unit:

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- A chi-square test for the goodness of fit
- A chi-square test for the independence of variables
- A chi-square test for the equality of more than two population proportions.

11.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss various applications of chi-square tests like:
    - o a chi-square test for the goodness of fit
    - o a chi-square test for the independence of variables
    - o a chi-square test for the equality of more than two population proportions

11.2 A CHI-SQUARE TEST FOR THE GOODNESS OF FIT

As discussed before, the data in chi-square tests is often in terms of counts or frequencies. The actual survey data may be on a nominal or higher scale of measurement. If it is on a higher scale of measurement, it can always be converted into categories. The real world situations in business allow for the collection of count data, e.g., gender, marital status, job classification, age and income. Therefore, a chi-square becomes a much sought after tool for analysis. The researcher has to decide what statistical test is implied by the chi-square statistic in a particular situation. Below are discussed common principles of all the chi-square tests. The principles are summarized in the following steps:

- State the null and the alternative hypothesis about a population.
- Specify a level of significance.
- Compute the expected frequencies of the occurrence of certain events under the assumption that the null hypothesis is true.
- Make a note of the observed counts of the data points falling in different cells
- Compute the chi-square value given by the formula.

$$\chi^2_{k-1} = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

NOTES

Where,

O_i = Observed frequency of i[th] cell

E_i = Expected frequency of i[th] cell

k = Total number of cells

$k-1$ = degrees of freedom

- Compare the sample value of the statistic as obtained in previous step with the critical value at a given level of significance and make the decision.

A goodness of fit test is a statistical test of how well the observed data supports the assumption about the distribution of a population. The test also examines that how well an assumed distribution fits the data. Many a times, the researcher assumes that the sample is drawn from a normal or any other distribution of interest. A test of how normal or any other distribution fits a given data may be of some interest.

Consider, for example, the case of the multinomial experiment which is the extension of a binomial experiment. In the multinomial experiment, the number of the categories k is greater than 2. Further, a data point can fall into one of the k categories and the probability of the data point falling in the i[th] category is a constant and is denoted by p_i where $i = 1, 2, 3, 4, ..., k$. In summary, a multinomial experiment has the following features:

- There are fixed number of trials.
- The trials are statistically independent.
- All the possible outcomes of a trial get classified into one of the several categories.
- The probabilities for the different categories remain constant for each trial.

Consider as an example that a respondent can fall into any one of the four non-overlapping income categories. Let the probabilities that the respondent will fall into any of the four groups may be denoted by the four parameters p_1, p_2, p_3 and p_4. Given these, the multinomial distribution with these parameters, and n the number of people in a random sample, specifies the probabilities of any combination of the cell counts.

Given such a situation, we may use a multinomial distribution to test how well the data fits the assumption of k probability $p_1, p_2, ..., p_k$ of falling into the k cells. The hypothesis to be tested is:

H_0: Probabilities of the occurrence of events $E_1, E_2, ..., E_k$ are given by the specified probabilities $p_1, p_2, ..., p_k$

H_1: Probabilities of the k events are not the p_i stated in the null hypothesis.

Such hypothesis could be tested using the chi-square statistics. Below are given a set of illustrated examples.

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Example 11.1: The manager of ABC ice-cream parlour has to take a decision regarding how much of each flavour of ice-cream he should stock so that the demands of the customers are satisfied. The ice-cream suppliers claim that among the four most popular flavors, 62 per cent customers prefer vanilla, 18 per cent chocolate, 12 per cent strawberry and 8 per cent mango. A random sample of 200 customers produces the results as given below. At the $\alpha = 0.05$ significance level, test the claim that the percentages given by the supplies are correct.

Flavour	Vanilla	Chocolate	Strawberry	Mango
Number preferring	120	40	18	22

Solution:

Let

p_v : proportion of customers preferring vanilla flavour.

p_c : proportion of customers preferring chocolate flavour.

p_s : proportion of customers preferring strawberry flavour.

p_m : proportion of customers preferring mango flavour.

H_0 : $p_v = 0.62, p_c = 0.18, p_s = 0.12, p_m = 0.08$

H_1 : Proportions are not that specified in the null hypothesis

The expected frequencies corresponding to the various flavors under the assumption that the null hypothesis is true are:

$$\text{Vanilla} = 200 \times 0.62 = 124$$

$$\text{Chocolate} = 200 \times 0.18 = 36$$

$$\text{Strawberry} = 200 \times 0.12 = 24$$

$$\text{Mango} = 200 \times 0.08 = 16$$

The computations for χ_3^2 are as under: $\sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$

Flavour	***O*** **(Observed Frequencies)**	***E*** **(Expected Frequencies)**	***O – E***	***(O – E)²***	$\frac{(O-E)^2}{E}$
Vanilla	120	124	– 4	16	0.129
Chocolate	40	36	4	16	0.444
Strawberry	18	24	– 6	36	1.500
Mango	22	16	6	36	2.250
Total					4.323

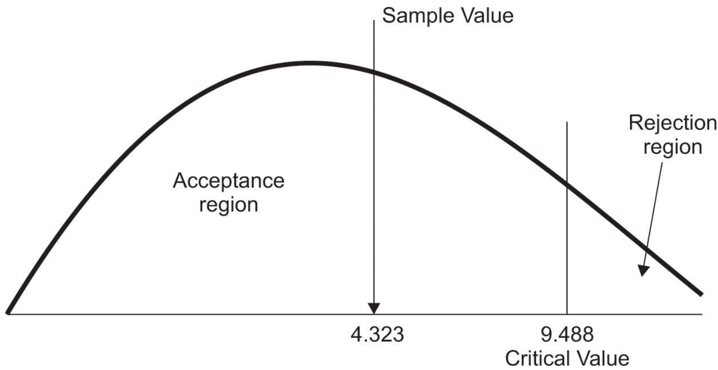
The computed value of chi-square is 4.323.

Table χ_3^2 (5 per cent) = 9.488 (see Table 11.1)

Table 11.1 *Some critical values of χ^2 for specified degrees of freedom*

Degrees of Freedom	Level of Significance		
	10%	**5%**	**1%**
1	2.706	3.841	6.635
2	4.605	5.991	9.210
3	6.251	7.815	11.345
4	7.779	9.488	13.277
5	9.236	11.071	15.086
6	10.645	12.592	16.812
7	12.017	14.067	18.475
8	13.362	15.507	20.090
9	14.684	16.919	21.666
10	15.987	18.307	23.209
11	17.275	19.675	24.725
12	18.549	21.026	26.217
13	19.812	22.362	27.688
14	21.064	23.685	29.141
15	22.307	24.996	30.578
16	23.542	26.296	32.000
17	24.769	27.587	33.409
18	25.989	28.869	34.805
19	27.204	30.144	36.191
20	28.412	31.410	37.566
21	29.615	32.671	38.932
22	30.813	33.924	40.289
23	33.007	35.172	41.638
24	33.196	36.415	42.980
25	34.382	37.652	44.314
26	35.363	38.885	45.642
27	36.741	40.113	46.963
28	37.916	41.337	48.278
29	38.087	42.567	49.588
30	40.256	43.773	50.892

Note: For degrees of freedom greater than 30, the quantity $\sqrt{2x^2} - \sqrt{2v-1}$ may be used as a normal variate with unit variance.



Rejection region for Example 11.1

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As sample χ^2 lies in the acceptance region, accept H_0. Therefore, the customer preference rates are as stated.

It may be worth pointing out that for the application of a chi-square test, the expected frequency in each cell should be at least 5.0. Further the sample observation should be independently and randomly taken. In case it is found that one or more cells have the expected frequency less than 5, one could still carry out the chi-square analysis by combining them into meaningful cells so that the expected number has a total of at least 5. Another point worth mentioning is that the degree of freedom, usually denoted by *df* in such cases, is given by $k - 1$, where k denotes the number of cells (categories).

It may be noted that in Example 11.1, the hypothesized probabilities were not equal. There are situations where the hypothesized probabilities in each category are equal or in other words, the interest is in investigating the uniformity of the distribution. The following example would illustrate it.

Example 11.2: An insurance company provides auto insurance and is analysing the data obtained from fatal crashes. A sample of the motor vehicle deaths is randomly selected for a two-year period. The number of fatalities is listed below for the different days of the week. At the 0.05 significance level, test the claim that accidents occur on different days with equal frequency.

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Number of fatalities	31	20	20	22	22	29	36

Solution:

Let

p_1 = Proportion of fatalities on Monday

p_2 = Proportion of fatalities on Tuesday

p_3 = Proportion of fatalities on Wednesday

p_4 = Proportion of fatalities on Thursday

p_5 = Proportion of fatalities on Friday

p_6 = Proportion of fatalities on Saturday

p_7 = Proportion of fatalities on Sunday

H_0 : $p_1 = p_2 = p_3 = p_4 = p_5 = p_6 = p_7 = \frac{1}{7}$

H_1 : At least one of these proportions is incorrect.

n = Total frequency = 31 + 20 + 20 + 22 + 22 + 29 + 36 = 180

The expected number of fatalities on each day of the week under the assumption that the null hypothesis is true is given as under:

$$\text{Monday} = 180 \times \frac{1}{7} = 25.714$$

$$\text{Tuesday} = 180 \times \frac{1}{7} = 25.714$$

$$\text{Wednesday} = 180 \times \frac{1}{7} = 25.714$$

$$\text{Thursday} = 180 \times \frac{1}{7} = 25.714$$

$$\text{Friday} = 180 \times \frac{1}{7} = 25.714$$

$$\text{Saturday} = 180 \times \frac{1}{7} = 25.714$$

$$\text{Sunday} = 180 \times \frac{1}{7} = 25.714$$

The computation of sample chi-square value is given in the following table:

Day	Observed Frequencies (O)	Expected Frequencies (E)	$O - E$	$(O - E)^2$	$\frac{(O-E)^2}{E}$
Monday	31	25.714	5.286	27.942	1.087
Tuesday	20	25.714	– 5.714	32.650	1.270
Wednesday	20	25.714	– 5.714	32.650	1.270
Thursday	22	25.714	– 3.714	13.794	0.536
Friday	22	25.714	– 3.714	13.794	0.536
Saturday	29	25.714	3.286	10.798	0.420
Sunday	36	25.714	10.286	105.802	4.114
Total					9.233

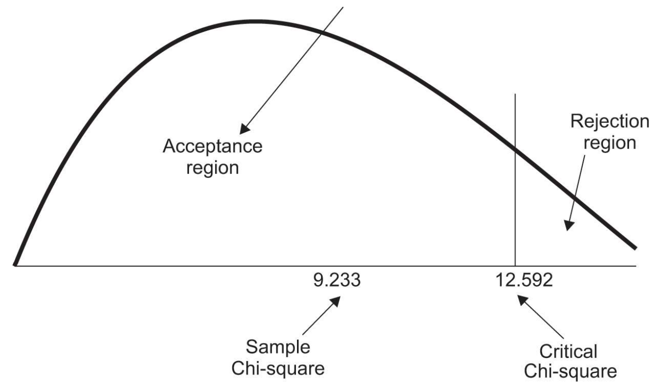
The value of sample $\chi^2 = \Sigma\frac{(O-E)^2}{E} = 9.233$

Degrees of freedom $= 7 - 1 = 6$

Critical (Table) $\chi^2_6 = 12.592$

Since the sample chi-square value is less than the tabulated χ^2, there is not enough evidence to reject the null hypothesis as shown in the figure below.

NOTES



Rejection region for Example 11.2

11.3 A CHI-SQUARE TEST FOR INDEPENDENCE OF VARIABLES

The chi-square test can be used to test the independence of two variables each having at least two categories. The test makes use of contingency tables, also referred to as cross-tabs with the cells corresponding to a cross classification of attributes or events. A contingency table with 3 rows and 4 columns (as an example) is shown in Table 11.2.

Table 11.2 *Contingency Table with 3 Rows and 4 Columns*

Second Classification Category	First Classification Category				
	1	2	3	4	Total
1	O_{11}	O_{12}	O_{13}	O_{14}	R_1
2	O_{21}	O_{22}	O_{23}	O_{24}	R_2
3	O_{31}	O_{32}	O_{33}	O_{34}	R_3
Total	C_1	C_2	C_3	C_4	n

Assuming that there are r rows and c columns, the count in the cell corresponding to the i^{th} row and the j^{th} column is denoted by O_{ij}, where i = 1, 2, ..., r and j = 1, 2, ..., c. The total for row i is denoted by R_i whereas that corresponding to column j is denoted by C_j. The total sample size is given by n, which is also the sum of all the r row totals or the sum of all the c column totals.

The hypothesis test for independence is:

H_0 : Row and column variables are independent of each other.

H_1 : Row and column variables are not independent.

The hypothesis is tested using a chi-square test statistic for independence given by:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

The degrees of freedom for the chi-square statistic are given by $(r-1)(c-1)$.

For a given level of significance α, the sample value of the chi-square is compared with the critical value for the degree of freedom $(r-1)(c-1)$ to make a decision.

The expected frequency in the cell corresponding to the i[th] row and the j[th] column is given by:

$$E_{ij} = \frac{R_i \times C_j}{n}$$

Where, R_i = Total for the i[th] row

C_j = Total for the j[th] column

n = Total sample size.

Let us consider a few examples:

Example 11.3: A sample of 870 trainees was subjected to different types of training classified as intensive, good and average and their performance was noted as above average, average and poor. The resulting data is presented in the table below. Use a 5 per cent level of significance to examine whether there is any relationship between the type of training and performance.

Performance	Training			
	Intensive	Good	Average	Total
Above average	100	150	40	290
Average	100	100	100	300
Poor	50	80	150	280
Total	250	330	290	870

Solution:

H_0 : Attribute performance and the training are independent.

H_1 : Attribute performance and the training are not independent.

The expected frequencies corresponding the i[th] row and the j[th] column in the contingency table are denoted by E_{ij}, where $i = 1, 2, 3$ and $j = 1, 2, 3$.

$$E_{1,1} = \frac{290 \times 250}{870} = 83.33$$

$$E_{1,2} = \frac{290 \times 330}{870} = 110.00$$

$$E_{1,3} = \frac{290 \times 290}{870} = 96.67$$

$$E_{2,1} = \frac{300 \times 250}{870} = 86.21$$

$$E_{2,2} = \frac{300 \times 330}{870} = 113.79$$

NOTES

$$E_{2,3} = \frac{300 \times 290}{870} = 100.00$$

$$E_{3,1} = \frac{280 \times 250}{870} \; 80.46$$

$$E_{3,2} = \frac{280 \times 330}{870} = 106.21$$

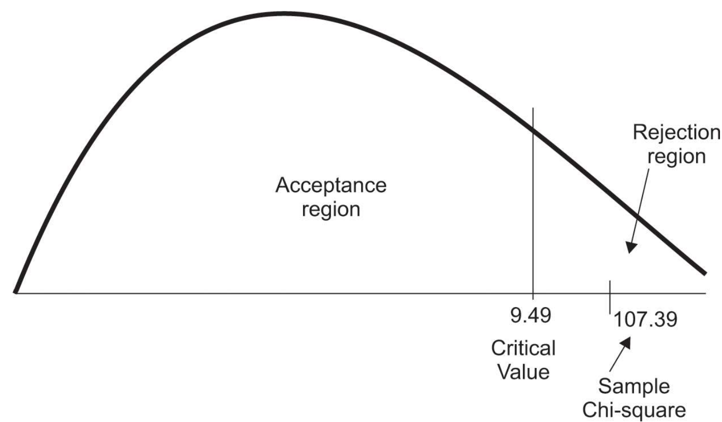
$$E_{3,3} = \frac{280 \times 290}{870} = 93.33$$

The table of the observed and expected frequencies corresponding to the i^{th} row and the j^{th} column and the computation of the chi-square are given in the table below.

Row, Column	O_{ij}	E_{ij}	$(O_{ij} - E_{ij})^2$	$\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$
1,1	100	83.33	277.89	3.335
1,2	150	110.00	1600.00	14.545
1,3	40	96.67	3211.49	33.221
2,1	100	86.21	190.16	2.21
2,2	100	113.79	190.16	1.671
2,3	100	100.00	0	0.000
3,1	50	80.46	927.81	11.53
3,2	80	106.21	686.96	6.468
3,3	150	93.33	3211.49	34.41
Total				107.39

$$\text{Sample } \chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 107.39$$

The critical value of the chi-square at 5 per cent level of significance with 4 degrees of freedom is given by 9.49. The sample value of the chi-square falls in the rejection region as shown in the figure below.



Rejection region for Example 11.3

NOTES

Therefore, the null hypothesis is rejected and one can conclude that there is an association between the type of training and performance.

Example 11.4: The following table gives the number of good and defective parts produced by each of the three shifts in a factory:

Shift	Good	Defective	Total
Day	900	130	1030
Evening	700	170	870
Night	400	200	600
Total	2000	500	2500

Is there any association between the shift and the equality of the parts produced? Use a 0.05 level of significance.

Solution:

H_0 : There is no association between the shift and the quality of parts produced.

H_1 : There is an association between the shift and quality of parts.

The computations of the expected frequencies corresponding to the i^{th} row and the j^{th} column of the contingency table are shown below: (i = 1, 2, 3) and (j = 1, 2).

$$E_{1,1} = \frac{1{,}030 \times 2{,}000}{2{,}500} = 824$$

$$E_{1,2} = \frac{1{,}030 \times 500}{2{,}500} = 206$$

$$E_{2,1} = \frac{870 \times 2{,}000}{2{,}500} = 696$$

$$E_{2,2} = \frac{870 \times 500}{2{,}500} = 174$$

$$E_{3,1} = \frac{600 \times 2{,}000}{2{,}500} = 480$$

$$E_{3,2} = \frac{600 \times 500}{2{,}500} = 120$$

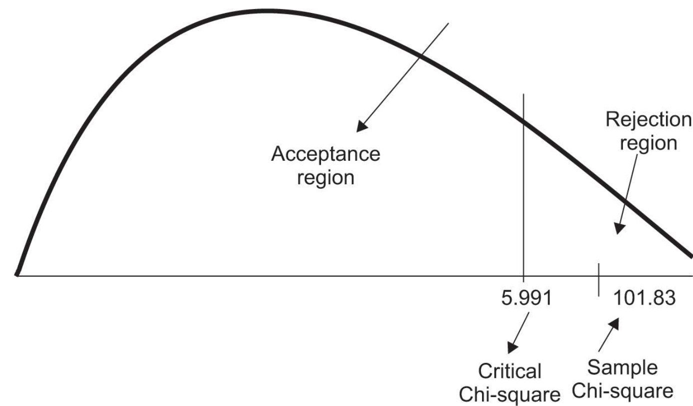
The table of the observed and expected frequencies corresponding to the i^{th} row and the j^{th} column and the computation of the chi-square is given below:

Row, Column	O_{ij}	E_{ij}	$(O_{ij} - E_{ij})^2$	$\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$
1,1	900	824	5776	7.010
1,2	130	206	5776	28.039
2,1	700	696	16	0.023
2,2	170	174	16	0.092
3,1	400	480	6400	13.333
3,2	200	120	6400	53.333
Total				**101.83**

The sample chi-square is $\chi^2 = \sum_{i=1}^{3}\sum_{j=1}^{2}\frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 101.83$

NOTES

The critical value of the chi-square with 2 degrees of freedom at 5 per cent level of significance is given by 5.991. The null hypothesis is rejected as the sample chi-square lies in the rejection region as shown in the figure below. Therefore, the quality of parts produced is related to the shifts in which they were produced.



Rejection region for Example 11.4

It may be worth mentioning again that for the application of a chi-square test of independence, the sample should be selected at random and the expected frequency in each cell should be at least 5.

Check Your Progress

1. What is a goodness of fit test?
2. State the minimum expected frequency in each cell required for the application of a chi-square test.
3. What is the assumption under which the expected frequencies in a cross table are computed?
4. Can the chi-square test of independence be applied in a case where the sample is selected by criteria and the expected frequency in each cell is at least 5?

11.4 A CHI-SQUARE TEST FOR THE EQUALITY OF MORE THAN TWO POPULATION PROPORTIONS

In certain situations, the researchers may be interested to test whether the proportion of a particular characteristic is the same in several populations. The interest may lie in finding out whether the proportion of people liking a movie is the

same for the three age groups — 25 and under, over 25 and under 50, and 50 and over. To take another example, the interest may be in determining whether in an organization, the proportion of the satisfied employees in four categories—class I, class II, class III and class IV employees—is the same. In a sense, the question of whether the proportions are equal is a question of whether the three age populations of different categories are homogeneous with respect to the characteristics being studied. Therefore, the tests for equality of proportions across several populations are also called tests of homogeneity.

The analysis is carried out exactly in the same way as was done for the other two cases. The formula for a chi-square analysis remains the same. However, two important assumptions here are different.

(i) We identify our population (e.g., age groups or various class employees) and the sample directly from these populations.

(ii) As we identify the populations of interest and the sample from them directly, the sizes of the sample from different populations of interest are fixed. This is also called a chi-square analysis with fixed marginal totals. The hypothesis to be tested is as under:

H_0 : The proportion of people satisfying a particular characteristic is the same in population.

H_1 : The proportion of people satisfying a particular characteristic is not the same in all populations.

The expected frequency for each cell could also be obtained by using the formula as explained earlier. There is an alternative way of computing the same, which would give identical results. This is shown in the following example:

Example 11.5: An accountant wants to test the hypothesis that the proportion of incorrect transactions at four client accounts is about the same. A random sample of 80 transactions of one client reveals that 21 are incorrect; for the second client, the number is 25 out of 100; for the third client, the number is 30 out of 90 sampled and for the fourth, 40 are incorrect out of a sample of 110. Conduct the test at $\alpha = 0.05$.

Solution:

Let p_1 = Proportion of incorrect transaction for 1st client

p_2 = Proportion of incorrect transaction for 2nd client

p_3 = Proportion of incorrect transaction for 3rd client

p_4 = Proportion of incorrect transaction for 4th client

Let H_0 : $p_1 = p_2 = p_3 = p_4$

H_1 : All proportions are not the same.

NOTES

The observed data in the problem can be rewritten as:

Transactions	Client 1	Client 2	Client 3	Client 4	Total
Incorrect transactions	21	25	30	40	116
Correct transactions	59	75	60	70	264
Total	80	100	90	110	380

An estimate of the combined proportion of the incorrect transactions under the assumption that the null hypothesis is true:

$$p = \frac{21+25+30+40}{80+100+90+110} = \frac{116}{380} = 0.305$$

$$q = \text{combined proportion of the correct transaction}$$
$$= 1 - p = 1 - 0.305 = 0.695$$

Using the above, the expected frequencies corresponding to the various cells are computed as shown below:

Transactions	Client 1	Client 2	Client 3	Client 4	Total
Incorrect transactions	80 × 0.305 = 24.4	100 × 0.305 = 30.5	90 × 0.305 = 27.45	110 × 0.305 = 33.55	115.9
Correct transactions	80 × 0.695 = 55.6	100 × 0.695 = 69.5	90 × 0.695 = 62.55	110 × 0.695 = 76.45	264.1
Total	80	100	90	110	380

In fact, the sum of each row/column in both the observed and expected frequency tables should be the same. Here, a bit of discrepancy is found because of the rounding of the error. It can be easily verified that the expected frequencies in each cell would be the same using the formula as $E_{ij} = \frac{R_i \times C_j}{n}$ already explained. Now the value of the chi-square statistic can be calculated as:

$$\chi^2 = \sum_{i=1}^{2}\sum_{j=1}^{4}\frac{(O_{ij} - E_{ij})^2}{E_{ij}} = \frac{(21-24.4)^2}{24.4} + \frac{(25-30.5)^2}{30.5} + \frac{(30-27.45)^2}{27.45} + \frac{(40-33.55)^2}{33.55}$$

$$+ \frac{(59-55.6)^2}{55.6} + \frac{(75-69.5)^2}{69.5} + \frac{(60-62.55)^2}{62.55} + \frac{(70-76.45)^2}{76.45}$$

$$= 0.474 + 0.992 + 0.237 + 1.240 + 0.208 + 0.435 + 0.104 + 0.544$$

$$= 4.234$$

Degrees of freedom (df) = (2 – 1) × (4 – 1) = 3

The critical value of the chi-square with 3 degrees of freedom at 5 per cent level of significance equals 7.815. Since the sample value of χ^2 is less than the critical value, there is not enough evidence to reject the null hypothesis. Therefore,

the null hypothesis is accepted. Therefore, there is no significant difference in the proportion of incorrect transaction for the four clients.

NOTES

Exercises

1. A sample analysis of the examination results of 200 MBA students was done. It was found that 46 students had failed, 68 had secured a third division, 62 had secured a second division and the rest obtained first division. Are these figures commensurate with the general examination result, which is in the ratio of 2 : 3 : 3 : 2 for various categories respectively?
2. Of the 1000 workers in a factory exposed to an epidemic, 700 in all were attacked, 400 had been inoculated and of these, 200 were attacked. On the basis of this information can it be said that the inoculation and attack are independent?
3. The following figures show the distribution of the digits in numbers chosen at random from a telephone directory:

Digit	0	1	2	3	4	5	6	7	8	9	Total
Frequency	1026	1107	997	966	1075	933	1107	972	964	853	10,000

   Test whether the digits may be taken to occur equally in the directory.
4. The number of automobile accidents per week in a certain city was as follows:

   12, 8, 20, 2, 14, 10, 15, 6, 9, 4

   Are these frequencies in agreement with the belief that the accident conditions were the same during the 10-week period?
5. The divisional manager of a retail chain believes that the average number of customers entering each of the five stores in his division weekly is the same. In a given week, a manager reports the following number of customers in the stores:

   3000, 2960, 3100, 2780, 3160

   Test the divisional manager's belief at a 10 per cent level of significance.
6. A cigarette company interested in the relation between sex of a person and the type of cigarettes smoked has collected the following data from a random sample of 150 persons:

Cigarette	Male	Female	Total
A	25	30	55
B	40	15	55
C	30	10	40
Total	95	55	150

   Test whether the type of cigarette smoked and the sex are independent.

NOTES

Check Your Progress

5. What is another name for tests for equality of proportions across several populations?
6. Mention the degrees of freedom for chi-square test, if there are 3 rows and two columns.

11.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. A goodness of fit test is a statistical test of how well the observed data supports the assumption about the distribution of a population.
2. For the application of a chi-square test, the expected frequency in each cell should be at least 5.0.
3. The expected frequencies in a cross table are computed under the assumption that null hypothesis is true.
4. No, for the application of a chi-square test of independence, the sample should be selected at random and the expected frequency in each cell should be at least 5.
5. The tests for equality of proportions across several populations are also called tests of homogeneity.
6. If there are 3 rows and two columns, the degrees of freedom for chi-square test is 3.

11.6 SUMMARY

- Chi-square test has a variety of applications in research. Chi-square is non-symmetrical distribution taking non-negative values.
- It can be used to test the goodness of fit of a distribution, independence of variables and equality of more than two population proportions.
- A necessary condition for the application of chi-square test is that the expected frequency in each cell should be at least 5.
- The first and foremost thing for the application of chi-square is the computation of expected frequencies.
- The data in chi-square test is in terms of counts or frequencies. In case the actual data is on a scale higher than that of nominal or ordinal, it can always be converted into categories.

11.7 KEY WORDS

- **Degrees of freedom:** These are given by $(r–1) \times (c–1)$ for a contigency table.
- **Chi-square distribution:** This is a non-symmetric distribution taking only non-negative values.
- **Non-symmetric distribution:** Those distributions that are skewed towards any one tail of the distribution.

11.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is chi-square test of the goodness of fit? What precautions are necessary while applying this test? Point out its role in business decision-making.
2. List the principles of the chi-square test.
3. What are the features of a multinomial experiment?

Long-Answer Questions

1. What is a χ^2 test? Point out its applications. Under what conditions is this test applicable?
2. A cigarette company interested in the relation between sex of a person and the type of cigarettes smoked has collected the following data from a random sample of 150 persons:

Cigarette	Male	Female	Total
A	25	30	55
B	40	15	55
C	30	10	40
Total	95	55	150

Test whether the type of cigarette smoked and the sex are independent.

3. A survey was carried out in a state among the doctors belonging to the rural health service cadre (500 doctors) and among the medical education directorate cadre (300 teaching doctors). They were asked a question, 'Would it be acceptable to you, if the government proposes to hire all the doctors on a fixed period contractual basis?' The doctors were to answer either as 'Acceptable' or 'Not Acceptable'. There was no third category

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'Undecided'. The following was the data compiled in a cross-tabulated format:

Doctors	Acceptable	Not Acceptable	Total
Rural Cadre	195	305	500
Teaching Cadre	140	160	300
Total	335	465	800

Test an appropriate hypothesis using a 5 per cent level of significance.

4. The following figures show the distribution of the digits in numbers chosen at random from a telephone directory:

Digit	0	1	2	3	4	5	6	7	8	9	Total
Frequency	1,026	1,107	997	966	1,075	933	1,107	972	964	853	10,000

Test whether the digits may be taken to occur equally in the directory.

11.9 FURTHER READINGS

Chawla D and Sondhi N. 2016. *Research Methodology: Concepts and Cases*, 2nd edition. New Delhi: Vikas Publishing House.

Kothari, C R. 1990. *Research Methodology: Methods and Techniques*. New Delhi: Wiley Eastern.

Zikmund, William G. 2000. *Business Research Methods*. Fort Worth: Dryden Press,

UNIT 12 ANALYSIS OF VARIANCE

NOTES

Structure

12.0 INTRODUCTION

In Unit 10, we discussed the test of hypothesis concerning the equality of two population means using both the *Z* and t tests. However, if there are more than two populations, the test for the equality of means could be carried out by considering two populations at a time. This would be a very cumbersome procedure. One easy way out could be to use the Analysis of Variance (ANOVA) technique. The technique helps in performing this test in one go and, therefore, is considered to be important technique of analysis for the researcher. Through this technique it is possible to draw inferences whether the samples have been drawn from populations having the same mean.

The technique has found applications in the fields of economics, psychology, sociology, business and industry. It becomes handy in situations where we want to compare the means of more than two populations. Some examples could be to compare:

- the mean cholesterol content of various diet foods
- the average mileage of, say, five automobiles
- the average telephone bill of households belonging to four different income groups and so on.

R A Fisher developed the theory concerning ANOVA. The basic principle underlying the technique is that the total variation in the dependent variable is broken into two parts—one which can be attributed to some specific causes and the other that may be attributed to chance. The one which is attributed to the specific causes is called the variation between samples and the one which is attributed to chance is termed as the variation within samples. Therefore, in ANOVA, the total variance may be decomposed into various components corresponding to the sources of the variation.

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In ANOVA, the dependent variable in question is metric (interval or ratio scale), whereas the independent variables are categorical (nominal scale). If there is one independent variable (one factor) divided into various categories, we have one-way or one-factor analysis of variance. In the two-way or two-factor analysis of variance, two factors each divided into the various categories are involved.

In ANOVA, it is assumed that each of the samples is drawn from a normal population and each of these populations has an equal variance. Another assumption that is made is that all the factors except the one being tested are controlled (kept constant). Basically, two estimates of the population variances are made. One estimate is based upon between the samples and the other one is based upon within the samples. The two estimates of variances can be compared for their equality using F statistic.

12.1 OBJECTIVES

After going through this unit, you will be able to:

- Explain the meaning and assumptions of conducting analysis of variance
- Describe completely randomized design
- Describe the randomized block design in two-way analysis of variance
- Explain a factorial design

12.2 COMPLETELY RANDOMIZED DESIGN IN A ONE-WAY ANOVA

Completely randomized design involves the testing of the equality of means of two or more groups. In this design, there is one dependent variable and one independent variable. The dependent variable is metric (interval/ratio scale) whereas the independent variable is categorical (nominal scale). A sample is drawn at random from each category of the independent variable. The size of the sample from each category could be equal or different. Let us consider a few examples to illustrate a one-way analysis of variance.

Example 12.1: Suppose we want to compare the cholesterol contents of the four competing diet foods on the basis of the following data (in milligrams per package) which were obtained for three randomly taken 6-ounce packages of each of the diet foods:

Diet Food A	3.6	4.1	4.0
Diet Food B	3.1	3.2	3.9
Diet Food C	3.2	3.5	3.5
Diet Food D	3.5	3.8	3.8

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We want to test whether the difference among the sample means can be attributed to chance at the 5 per cent level of significance.

Solution: As explained earlier, the total variation in the data set can be expressed as a sum of the variations that can be attributed to specific sources (in this example, the various diet foods) plus the one which is attributed due to chance. The total variation in the data set is called the total sum of squares (TSS) and is computed as:

$$\text{TSS} = \sum_{i=1}^{k}\sum_{j=1}^{n} x_{ij}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

Where, $(i = 1, \ldots k \text{ and } j = 1, 2, \ldots. n)$

x_{ij} = the j[th] observation of the i[th] sample (diet food)

$T_{\bullet\bullet}$ = Grand total of all the data

k = 4 (Number of diet foods)

n = 3 (number of observations in each sample)

The term $\frac{1}{kn} \bullet T_{\bullet\bullet}^2$ is referred to as the correction factor. The variation between the sample means which is attributed to specific sources or causes is referred to as the treatment sum of squares (TrSS). This is computed using the following formula:

$$\text{TrSS} = \frac{1}{n}\sum_{i=1}^{k} T_{i\bullet}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

Where, $T_{i\bullet}$ = Total of observations for the ith treatment.

The variation within the sample, which is attributed to chance, is referred to as the error sum of squares (SSE). This could be computed by subtracting the treatment sum of squares from the total sum of squares. This is shown as:

$$\text{SSE} = \text{TSS} - \text{TrSS}$$

$$= \left[\sum_{i=1}^{k}\sum_{j=1}^{n} x_{ij}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2\right] - \left[\frac{1}{n}\sum_{i=1}^{k} T_{i\bullet}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2\right]$$

In order to test the null hypothesis,

H_0 : $\mu_A = \mu_B = \mu_C = \mu_D$

against the alternative hypothesis

H_1 : At least two means are not equal

(Treatment means are not equal)

We test the equality of TrSS with SSE. The necessary workings required for this are presented in Table 12.1, which is called one-way analysis of the variance table. The first column of the table indicates the sources of variation. The second column lists the degrees of freedom. There are k treatments; therefore the

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corresponding degrees of freedom are $k - 1$. Similarly, the total number of observations in the data set is kn and therefore, the corresponding degrees of freedom are $kn - 1$. The degrees of freedom for errors are obtained by subtracting from the total degrees of freedom, the degrees of freedom corresponding to the treatment, i.e., $(kn - 1) - (k - 1) = k(n - 1)$. The third column lists the sum of squares due to the various sources of variation. The fourth column lists the mean square due to treatment MSTr = (TrSS/k–1) and the mean square due to error MSE = (SSE/k(n–1)) obtaining by dividing the corresponding sum of squares by their degrees of freedom. The last column indicates the F statistic given as the ratio of the two mean squares with k–1 degrees of freedom for the numerator and k(n–1) degrees of freedom for the denominator. For a given level of significance, the computed F statistic is compared with the table value of F with k–1 degrees of freedom in the numerator and k(n–1) degrees of the freedom for the denominator. If the computed F value is greater than the tabulated F value, the null hypothesis is rejected.

Table 12.1 *One-way ANOVA*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	$F^{k-1}_{k(n-1)}$
Treatments (Diet food)	$k - 1$	TrSS	$MSTr = \frac{TrSS}{k-1}$	$\frac{MSTr}{MSE}$
Error	$k(n - 1)$	SSE	$MSE = \frac{SSE}{k(n-1)}$	
Total	$kn - 1$	TSS		

The required computations in case of Example 12.1 are given below:

$k = 4, n = 3$

$T_{..}$	=	3.6 + 4.1 + 4.0 + 3.1 + 3.2 + 3.9 + 3.2 + 3.5 + 3.5 + 3.5 + 3.8 + 3.8	=	43.2
$T_{1.}$	=	3.6 + 4.1 + 4.0	=	11.7
$T_{2.}$	=	3.1 + 3.2 + 3.9	=	10.2
$T_{3.}$	=	3.2 + 3.5 + 3.5	=	10.2
$T_{4.}$	=	3.5 + 3.8 + 3.8	=	11.1
$\sum_{i=j}^{4}\sum_{j=1}^{3} x_{ij}^2$	=	$(3.6)^2 + (4.1)^2 + (4.0)^2 + (3.1)^2 + (3.2)^2 + (3.9)^2 + (3.2)^2 + (3.5)^2 + (3.5)^2 + (3.5)^2 + (3.8)^2 + (3.8)^2$	=	156.70

$$\text{TSS} = \sum_{i=j}^{4}\sum_{j=1}^{3} x_{ij}^2 - \frac{1}{kn} \bullet T_{..}^2 = 156.70 - \frac{1}{12}(43.2)^2 = 1.18$$

$$\text{TrSS} = \frac{1}{n}\sum_{i=1}^{4} T_{i.}^2 - \frac{1}{kn} \bullet T_{..}^2$$

$$= \frac{1}{3}[11.7^2 + 10.2^2 + 10.2^2 + 11.1^2] - \frac{1}{12}(43.2)^2 = 0.54$$

$$\text{SSE} = \text{TSS} - \text{TrSS}$$

$$= 1.18 - 0.54 = 0.64$$

The above results corresponding to Example 12.1 could be set up in the ANOVA Table 12.2.

Table 12.2 *ANOVA Table for Example 12.1*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F^3_8
Treatments (Diet Food)	3	0.54	0.18	2.25
Error	8	0.64	0.08	
Total	11	1.18		

Assuming the level of significance to be 5 per cent, the table value of *F* with 3 degrees of freedom in the numerator and 8 degrees of freedom in the denominator equals 4.07 (See Table 12.3). Since the computed *F* is less than the tabulated *F*, there is not enough evidence to reject the null hypothesis. Therefore, the difference in the cholesterol contents in the four diet foods could be attributed to chance.

A mentioned earlier, the size of the sample from each category (treatment) need not be same. If there are ni observations corresponding to ith treatment, the computing formula for the sum of squares would look like:

$$\text{TSS} = \sum_{i=j}^{k}\sum_{j=1}^{n_i} x_{ij}^2 - \frac{1}{N} \bullet T_{\cdot\cdot}^2$$

$$\text{TrSS} = \sum_{i=1}^{k} \frac{T_{1\cdot}^2}{n_i} - \frac{1}{N} T_{\cdot\cdot}^2$$

$$\text{SSE} = \text{TSS} - \text{TrSS}$$

Where, $N = n_1 + n_2 + \ldots + n_k$

The total number of degrees of freedom in the case is N – 1, and the degrees of freedom are $k - 1$ for the treatments and $N - k$ for the error. Let us consider an example.

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Table 12.3(a) *Significance points of the variance-ratio 'F' 5 per cent points of F*

$v_2 \downarrow$ \ $v_1 \rightarrow$	1	2	3	4	5	6	8	12	24	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	249.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.45	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.84	8.74	8.64	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.77	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.53	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.84	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.41	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.12	3.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.90	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.74	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.61	2.40
12	4.75	3.88	3.49	3.26	3.11	3.00	2.85	2.69	2.50	2.30
13	4.67	3.80	3.41	3.18	3.02	3.92	2.77	2.60	2.42	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.35	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.29	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.24	2.01
17	4.45	3.59	3.20	2.96	2.81	3.70	2.55	2.38	2.19	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.15	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.11	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.08	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.42	2.25	2.05	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.03	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.38	2.20	2.00	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	1.98	1.73
25	4.24	3.38	2.99	2.76	2.60	2.49	2.34	2.16	1.96	1.71
26	4.22	3.37	2.98	2.74	2.59	2.47	2.32	2.15	1.95	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.30	2.13	1.93	1.67
28	4.20	3.34	2.95	2.71	2.56	2.44	2.29	2.12	1.91	1.65
29	4.18	3.33	2.93	2.70	2.54	2.43	2.28	2.10	1.90	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2 .27	2.09	1.89	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.79	1.51
60	4.00	3.15	2.76	2.52	2.37	2.25	2.10	1.92	1.70	1.89
120	2.92	3.07	2.68	2.45	2.29	2.17	2.02	1.83	1.61	1.25
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.52	1.00

v_1 = Degrees of freedom for greater variance.

v_2 = Degrees of freedom for smaller variance.

Table 12.3(b) *Significance points of the variance-ratio 'F'1 per cent points of F*

NOTES

$v_1 \rightarrow$ / $v_2 \downarrow$	1	2	3	4	5	6	8	12	24	∞
1	4052	5000	5403	5625	5764	5859	5982	6106	6235	6366
2	98.50	99.00	99.17	99.25	99.30	99.33	99.37	99.42	99.46	99.50
3	34.12	30.82	29.46	28.71	28.24	27.91	27.49	27.05	26.60	26.13
4	21.20	18.20	16.69	15.88	15.52	15.21	14.80	14.37	13.93	13.45
5	16.26	13.27	12.06	11.39	10.97	10.67	10.29	9.89	9.47	9.02
6	13.75	10.92	9.78	9.15	8.75	8.47	8.10	7.72	7.31	6.88
7	12.25	9.55	8.45	7.85	7.46	7.19	6.84	6.47	6.07	5.65
8	11.26	8.65	7.59	7.01	6.63	6.37	6.03	5.67	5.28	4.86
9	10.56	8.02	6.99	6.42	6.06	5.80	5.47	5.12	4.73	4.31
10	10.04	7.56	6.55	5.99	5.64	5.39	5.06	4.71	4.33	3.91
11	9.65	7.21	6.22	5.87	5.32	5.07	4.74	4.40	4.02	3.60
12	9.33	6.93	5.95	5.41	5.06	4.82	4.50	4.16	3.78	3.36
13	9.07	6.70	5.74	5.21	4.86	4.62	4.30	3.96	3.59	3.17
14	8.86	6.51	5.56	5.04	4.69	4.46	4.14	3.80	3.43	3.00
15	8.68	6.36	4.42	4.89	4.56	4.32	4.00	3.67	3.29	2.87
16	8.53	6.23	5.29	4.77	4.44	4.20	3.89	3.55	3.18	2.75
17	8.40	6.11	5.18	4.67	4.34	4.10	3.79	3.46	3.08	2.65
18	8.29	6.01	5.09	4.58	4.25	4.01	3.71	3.37	3.00	2.59
19	8.18	5.93	5.01	4.50	4.17	3.94	3.63	3.30	3.92	2.49
20	8.10	5.85	4.94	4.43	4.10	3.87	3.56	3.23	2.86	2.42
21	8.02	5.78	4.87	4.37	4.04	3.81	3.51	3.17	2.80	2.36
22	7.95	5.72	4.82	4.31	3.99	3.76	3.45	3.12	2.75	2.31
23	7.88	5.66	4.76	4.26	3.94	3.71	3.41	3.07	2.70	2.26
24	7.82	5.61	4.72	4.22	3.90	3.67	3.36	3.03	2.66	2.21
25	7.77	5.57	4.68	4.18	3.85	3.63	3.32	2.99	2.62	2.17
26	7.72	5.53	4.64	4.14	3.82	3.59	3.20	2.96	2.58	2.10
27	7.68	5.49	4.60	4.11	3.78	3.56	3.26	2.93	2.45	2.13
28	7.64	5.45	4.57	4.07	3.75	3.53	3.23	2.90	2.52	2.06
29	7.60	5.42	4.54	4.04	3.73	3.50	3.20	2.87	2.49	2.03
30	7.56	5.39	4.51	4.02	3.70	3.47	3.17	2.84	2.47	2.01
40	7.31	5.18	4.31	3.83	3.51	3.29	2.99	2.66	2.29	1.80
60	7.08	4.98	4.13	3.65	3.34	3.12	2.82	2.50	2.12	1.60
120	6.85	4.79	3.95	3.48	3.17	2.96	2.66	2.34	1.95	1.38
∞	6.64	4.60	3.78	3.32	3.02	2.80	2.51	2.18	1.79	1.00

v_1 = Degrees of freedom for greater variance.

v_2 = Degrees of freedom for smaller variance.

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Example 12.2: The following are the number of kilometres/litre which a test driver with three different types of cars has obtained randomly on different occasions.

Car 1	15	14.5	14.8	14.9		
Car 2	13	12.5	13.6	13.8	14	
Car 3	12.8	13.2	12.7	12.6	12.9	13

Using a 5 per cent level of significance, perform a one-way ANOVA to examine the hypothesis that the difference in the average mileage in the three types of cars can be attributed to chance.

Solution:

$H_0 : \mu_1 = \mu_2 = \mu_3$ (Average mileage in the three types of cars is the same.)

H_1 : At least two types of cars do not have the same mileage.

$K = 3, n_1 = 4, n_2 = 5, n_3 = 6$

$N = n_1 + n_2 + n_3 = 4 + 5 + 6 = 15$

$T_{..}$	=	15 + 14.5 + 14.8 + 14.9 + 13 + 12.5 + 13.6 + 13.8 + 14 + 12.8 + 13.2 + 12.7 + 12.6 + 12.9 + 13	=	203.3
$T_{1.}$	=	15 + 14.5 + 14.8 + 14.9	=	59.2
$T_{2.}$	=	13 + 12.5 + 13.6 + 13.8 + 14	=	66.9
$T_{3.}$	=	12.8 + 13.2 + 12.7 + 12.6 + 12.9 + 13	=	77.2
$\sum_{i=j}^{3}\sum_{j=1}^{8} x_{ij}^2$	=	$(15)^2 + (14.5)^2 + (14.8)^2 + (14.9)^2 + (13)^2 + (12.5)^2 + (13.6)^2 + (13.8)^2 + (14)^2 + (12.8)^2 + (13.2)^2 + (12.7)^2 + (12.6)^2 + (12.9)^2 + (13)^2$	=	2766.49

$$\text{TSS} = \sum_{i=1}^{3}\sum_{j=1}^{ni} x_{ij}^2 - \frac{1}{N} \bullet T_{..}^2$$

$$= 2766.49 - \frac{1}{15}(203.3)^2$$

$$= 2766.49 - 2755.393$$

$$= 11.097$$

$$\text{TrSS} = \sum_{i=1}^{3} \frac{T_{i.}^2}{n_i} - \frac{1}{N} T_{..}^2$$

$$= \left[\frac{59.2^2}{4} + \frac{66.9^2}{5} + \frac{77.2^2}{6}\right] - \frac{1}{15}(203.3)^2$$

$$
\begin{aligned}
&= 2764.5886 - 2755.3926 \\
&= 9.196 \\
SSE &= TSS - TrSS \\
&= 11.097 - 9.196 \\
&= 1.901
\end{aligned}
$$

NOTES

The ANOVA table in the case of Example 12.2 can be set up as shown in Table 12.4.

Table 12.4 *One-way ANOVA for Example 12.2*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F_{12}^{2}
Treatments (Between groups)	2	9.196	4.598	29.02
Error (within groups)	12	1.901	0.158	
Total	14	11.097		

The computed F statistics equals 29.02. The table value of *F* with 2 degrees of freedom in the numerator and 12 degrees of freedom in the denominator at a 5 per cent level of significance is given by 3.89. As the computed *F* statistic is greater than the table *F* value, the null hypothesis is rejected. Therefore, the average mileage in these types of cars is statistically different.

Check Your Progress

1. What is the nature of the dependent and independent variables in a completely randomized design?
2. What does the fourth column of a one-way analysis of the variance table denote?

12.3 RANDOMIZED BLOCK DESIGN IN TWO-WAY ANOVA

In Example 12.1, it could not be shown that there really is a significant difference in the average cholesterol content of the four diet foods. The results were not statistically different because there was a considerable difference in the values within each of the samples resulting in a large experimental error. However, if we have additional information that each of the value was randomly measured in the three different laboratories in such a way that the first value of each sample came from laboratory 1, the second value from laboratory 2, and the third value from laboratory 3 (the random assignment of test units to labs). In such a case, a two-way analysis of variance is suggested. We had earlier partitioned the total sum of

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squares into two components—one which is due to the differences between the sample (treatment sum of squares) and the other one due to the differences within the samples (error sum of squares). Now, this error sum of square includes the sum of squares due to laboratories (called blocks) as an extraneous factor. In two-way analysis of variance, we remove the effect of the extraneous factors (laboratories or blocks) from the error sum of squares. Therefore, the total sum of square is partitioned into three components—one due to treatment, second due to block and the third one due to chance (called the error sum of squares). It may be noted that the total sum of squares (TSS) and the treatment sum of squares (TrSS) would remain the same as computed earlier in Example 12.1. In addition, we will have another component called block sum of squares (SSB) which is due to different laboratories and is computed as:

$$\text{SSB} = \frac{1}{k} \bullet \sum_{j=1}^{n} T_{\bullet j}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

Where, $T_{\bullet j}$ = Total of the values in the j[th] block.

The error sum of squares would be computed as:

$$\text{SSE} = \text{TSS} - \text{TrSS} - \text{SSB}$$

There will be two hypotheses to be tested:

I (Diet Food)

H_0 : $\mu_A = \mu_B = \mu_C = \mu_D$

H_1 : At least the two means are not same.

II (Blocks or Labs)

H_0 : $\nu_1 = \nu_2 = \nu_3$

(Average cholesterol content in the three labs is same.)

H_1 : At least two means are not same.

Now, we would need to test the equality of TrSS with SSE and SSB with SSE. The necessary working required for this are presented in Table 12.5 called two-way analysis of variance table.

Table 12.5 *Two-way ANOVA*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Treatments	$k-1$	TrSS	$MSTr = \frac{TrSS}{k-1}$	$F^{k-1}_{(k-1)(n-1)} = \frac{MSTr}{MSE}$
Blocks	$n-1$	SSB	$MSB = \frac{SSB}{n-1}$	$F^{n-1}_{(k-1)(n-1)} = \frac{MSB}{MSE}$
Error	$(k-1)(n-1)$	SSE	$MSE = \frac{SSE}{(k-1)(n-1)}$	
Total	$kn-1$	TSS		

The various columns of the above table are filled up in the same fashion as was done for Table 12.1. Example 12.1 can be rewritten as Example 12.3.

Example 12.3: Suppose in Example 12.1, the measurement of the cholesterol content was performed in three different laboratories. The first value of each sample came from one laboratory, the second value came from another laboratory, and the third value came from a third laboratory. The data is presented below:

Diet Food	Laboratory		
	One	Two	Three
Diet Food A	3.6	4.1	4.0
Diet Food B	3.1	3.2	3.9
Diet Food C	3.2	3.5	3.5
Diet Food D	3.5	3.8	3.8

Perform a two-way ANOVA using a 0.05 level of significance.

Solution: There will be two hypotheses to be tested in this case; one corresponding to the treatment (diet food) and the other corresponding to laboratories (blocks). These are listed below:

I (Diet Food)

H_0 : $\mu_A = \mu_B = \mu_C = \mu_D$ (Average cholesterol content of the four diet foods is same.)

H_1 : At least two means are not same.

II (Blocks or labs)

H_0 : $\nu_1 = \nu_2 = \nu_3$ (Average cholesterol content in the three labs is same.)

H_1 : At least two means are not same.

The TSS and TrSS here would be the same as computed in Example 12.1. As mentioned earlier, the block sum of square would be required in this problem using the formula:

$$SSB = \frac{1}{k} \bullet \sum_{j=1}^{n} T_{\bullet j}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

Where, $T_{\bullet j}$ = Total of the values in the j^{th} block.

The error sum of squares would be obtained as

$$SSE = TSS - TrSS - SSB$$

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The required computations for the two-way ANOVA are as under:

$$T_{\bullet 1} = 3.6 + 3.1 + 3.2 + 3.5 = 13.4$$

$$T_{\bullet 2} = 4.1 + 3.2 + 3.5 + 3.8 = 14.6$$

$$T_{\bullet 3} = 4.0 + 3.9 + 3.5 + 3.8 = 15.2$$

$$\text{SSB} = \frac{1}{k} \bullet \sum_{j=1}^{n} T_{\bullet j}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

$$= \frac{1}{4}\ [13.4^2 + 14.6^2 + + 15.2^2] - \frac{1}{12}\ (43.2)^2$$

$$= 155.94 - 155.52$$

$$= 0.42$$

We have already computed in Example 12.1, the values of TSS and TrSS as under:

$$\text{TSS} = 1.18,\ \text{TrSS} = 0.54$$

$$\text{Therefore, SSE} = \text{TSS} - \text{TrSS} - \text{SSB}$$

$$= 1.18 - 0.54 - 0.42$$

$$= 0.22$$

We note that the SSE in Example 12.1 was 0.64, whereas here it is 0.22. This is because the earlier SSE has been partitioned into two components, namely, the block sum of squares (SSB) having a value of 0.42 resulting in 0.22 as the new error sum of squares (SSE). The required results for the testing of the two hypotheses are presented in the ANOVA Table 12.6.

Table 12.6 *Two-way ANOVA Table for Example 12.3*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	*F*
Treatments (Diet Food)	3	0.54	0.18	$F_6^3 = \frac{0.18}{0.0367} = 4.90$
Block (Laboratories)	2	0.42	0.21	$F_6^2 = \frac{0.21}{0.0367} = 5.72$
Error (Chance)	6	0.22	0.0367	
Total	11	1.18		

The table value of F_6^3 and F_6^2 at a 5 per cent level of significance is given by 4.76 and 5.14 respectively. The corresponding sample *F* values for both are 4.90 and 5.72. Since the computed *F* values are greater than the corresponding table values, the null hypothesis is rejected in both the cases. Therefore, it can be concluded that there is a difference in the average cholesterol content due to various diet foods and because of the laboratories where the measurements were taken.

Check Your Progress

3. What are the three components under which the total sum of square is partitioned?
4. Which variable's effect is removed in a randomized block design?

12.4 FACTORIAL DESIGN

In factorial design, the dependent variable is the interval or the ratio scale and there are two or more independent variables which are nominal scale. In the factorial design, it is possible to examine the interaction between the variables. If there are two independent variables each having three cells, there would be a total of nine interactions. The details on this are already explained in Unit 3 (Research Design). The main advantage of factorial design over randomized block design is that it is possible to measure the main effects as well as the interaction effects of two or more independent variables at various levels. Further, the randomized block design has only two independent variables whereas, factorial design can take care of more than two independent variables. Let us consider an illustration to explain factorial design.

It is generally observed that there are differences in the pay packages offered to fresh MBA graduates. The variations could be either due to the type of business school where they have studied or it could be due to their area of specialization. The variation can also be due to an interaction between the business school and the area of specialization. For example, the specialization in finance at one business school might fetch a better package. All these presumptions could be tested with the help of the factorial design explained with the help of the following example.

Example 12.4: The following data refers to the salary package (in ₹lakhs) offered to MBA graduates with different specializations and having studied at four different business schools. For the sake of simplification, only two students are taken for each interaction between the institute and field of specialization.

Specialization	Business School			
	I	II	III	IV
Marketing	6	4	8	6
	5	5	6	4
Finance	7	6	6	9
	6	7	7	8
Operations	8	5	10	9
	7	5	9	10

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Test the hypothesis (i) whether the difference between the pay packages offered can be attributed to chance (ii) average pay packages by all specializations are equal. (iii) the average pay package for 12 interactions are equal.

You may use a 5 per cent level of significance.

Solution: The following set of hypotheses is required to be tested.

Business schools:

H_0 : Average pay package for all the institutions are equal.

H_1 : Average pay package for all the institutions are not equal

Specialization:

H_0 : Average pay package for all the specializations are equal.

H_1 : Average pay package for all the specializations are not equal

Interaction:

H_0 : Average pay package for all 12 interactions are equal.

H_1 : Average pay package for all 12 interactions are not equal

Let us compute the following:

$$\text{Correction factor (CF)} = \frac{(\text{Sum of all observations})^2}{\text{Total number of observations}}$$

$$= \frac{(163)^2}{24} = \frac{26569}{24} = 1107.04$$

Total sum of squares = (Sum of squares of observations) – CF

$= 6^2 + 4^2 + 8^2 + 6^2 + \text{- - -} + 7^2 + 5^2 + 9^2 + 10^2 - 1107.04$

$= 1179 - 1107.04$

$= 71.96$

Sum of squares due to specialization (row)/SSR

$$= \frac{44^2}{8} + \frac{56^2}{8} + \frac{63^2}{8} - \text{CF}$$

$= 1130.13 - 1107.04$

$= 23.08$

Where,

Sum total for Marketing = 44

Sum total for Finance = 56

Sum total for Operations = 63

Sum of squares due to school (column)/SSC

$$= \frac{39^2}{6} + \frac{32^2}{6} + \frac{46^2}{6} + \frac{46^2}{6} - \text{CF}$$

= 1129.5 – 1107.04

= 22.46

Where,

Sum total for Business School I = 39

Sum total for Business School II = 32

Sum total for Business School III = 46

Sum total for Business School IV = 46

Sum of squares due to interactions (SSI) = $n \sum (\overline{x}_{ij} - \overline{x}_{i\bullet} - \overline{x}_{\bullet j} + \overline{x}_{\bullet\bullet})^2$

Where,

n = number of observations for each interaction

$\overline{x}_{i\bullet}$ = Mean of observations of i^{th} row

$\overline{x}_{\bullet j}$ = Mean of observation of j^{th} column

$\overline{x}_{\bullet\bullet}$ = Grand mean of all the observations.

$\overline{x}_{ij}$ = Mean of observation of i^{th} row and j^{th} column

The above terms can be calculated by first calculating the means of all the interactions and also the means of the corresponding rows and columns. These are presented in the table below:

Specialization	Business School				
	I	II	III	IV	$\overline{x}_{i\bullet}$
Marketing	5.5	4.5	7	5	5.5
Finance	6.5	6.5	6.5	8.5	7
Operations	7.5	5	9.5	9.5	7.88
$\overline{x}_{\bullet j}$	6.5	5.33	7.67	7.67	$\overline{x}_{\bullet\bullet}$ = 6.793

Therefore,

$$\text{SSI} = 2\sum\sum(\overline{x}_{ij} - \overline{x}_{i\bullet} - \overline{x}_{\bullet j} + \overline{x}_{\bullet\bullet})^2$$

$= 2[5.5 - 5.5 - 6.5 + 6.79)^2 + (4.5 - 5.5 - 5.33 +$

6 . 7 9) 2

$+ (9.5 - 7.88 - 7.67 + 6.79)^2]$

$= 2 \times 8.96 = 17.92$

Sum of Squares due to error (SSE):

SSE = TSS – SSR – SSC – SSI

= 71.96 – 23.08 – 22.46 – 17.92

= 8.5

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Therefore, the ANOVA table for factorial design could be prepared as given in Table 12.7.

Table 12.7 *Results of ANOVA Table for Factorial Design*

Sources of Variation	Sum of Squares	Degrees of Freedom	Mean Sum of Squares	F
Row (Specialization)	23.08	2	11.54	16.26
Column (Business School)	22.46	3	7.49	10.55
Interaction	17.92	6	2.96	4.17
Error	8.50	12	0.71	
Total	71.96	23		

The table values of F_{12}^{2}, F_{12}^{3} and F_{12}^{6} (at 5 per cent level of significance) are given as 3.885, 3.490 and 2.996 respectively. As the computed value for the hypothesis concerning specialization, business school and interaction are greater than the corresponding tabulated values; the three null hypotheses are rejected. This means that it can be concluded that the packages offered to the graduates vary due to their specialization, the type of business school in which they have studied and their interactions.

Check Your Progress

5. State the total number of interactions in a factorial design with two independent variables, one having two categories and second having three categories.
6. What is the main advantage of factorial design over randomized block design?

12.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. In a completely randomized design, the dependent variable is metric (interval/ ratio scale) whereas the independent variable is categorical (nominal scale).
2. The fourth column of a one-way analysis of the variance table denotes the mean square.
3. The total sum of square is partitioned into three components—one due to treatment, second due to block and third one due to chance.
4. In a randomized block design, the effect of one extraneous variable is removed.

5. In a factorial design with two independent variables, one having two categories and second having three categories, the total number of interactions is six.
6. The main advantage of factorial design over randomized block design is that it is possible to measure the main effects as well as the interaction effects of two or more independent variables at various levels.

12.6 SUMMARY

- RA Fisher developed the theory of analysis of variance. This technique could be used to test the equality of more than two population means in one go. The basic principle underlying the technique is that the total variations in the dependent variable can be broken into two components—one which can be attributed to specific causes and the other one may be attributed to chance. In analysis of variance, the dependent variable is metric, where as, the independent variable is categorical (nominal scale).
- The analysis of variance techniques in this unit are illustrated through the completely randomized design, randomized block design and factorial design.
- In a completely randomized design, there is one dependent and one independent variable. The dependent variable is metric whereas the independent variable is categorical. Random samples are drawn from each category of the independent variable. The sample size from each category could be same or different.
- In the randomized block design, there is one independent variable and one extraneous factor (block). Both independent variable and extraneous factor (block) are nominal scale variables. The effect of the extraneous factor is removed from the analysis.
- In factorial design, the dependent variable is metric and there are two or more independent variables which are non-metric. In this design, it is possible to examine the interaction between the variables. If there are two independent variables each having three cells, there would be a total of nine interactions.

12.7 KEY WORDS

- **Analysis of variance:** A technique used to compare means of two or more samples (using the F distribution). This technique can be used only for numerical data.

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- **Completely randomized design:** A design that involves the testing of the equality of means of two or more groups; there is one dependent variable and one independent variable in this design.
- **Factorial design:** A design for an experiment that allows the experimenter to find out the effect of two or more independent variables each having two or more categories along with their interactions on dependent variable.
- **One-way ANOVA:** A technique that compares the mean of two or more groups based on one independent variable (or factor).
- **Two-way ANOVA:** A statistical test used to determine the effect of two nominal predictor variables on a continuous outcome variable. A two-way ANOVA test analyzes the effect of the independent variables on the expected outcome along with their relationship to the outcome itself.

12.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What are the characteristics of randomized block design?
2. Explain the meaning of interaction between the variables with the help of a suitable example.

Long-Answer Questions

1. What is the analysis of variance? What are the assumptions of the technique? Give a few examples where the technique could be used.
2. Differentiate using suitable examples between the one-way and two-way analysis of variance.
3. What is a factorial design? Explain the terms, main effects and interaction effects in relation to factorial design.
4. The following data represents the numbers of units produced by four operators during three different shifts:

Shifts	Operator			
	A	B	C	D
I	10	8	12	13
II	10	12	14	15
III	12	10	11	14

Perform a two-way analysis of variance and interpret the result.

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12.9 FURTHER READINGS

Chawla D and Sondhi N. 2016. *Research Methodology: Concepts and Cases*, 2nd edition. New Delhi: Vikas Publishing House.

Cooper, Donald R and Schindler, P S. 1998. *Business Research Method*. 6th edn. New Delhi: Tata McGraw Hill Publishing Company Ltd,.

Kinnear, Thomas C and Taylor, J R. 1996. *Marketing Research: An Applied Approach.* 5th edn. New York: McGraw Hill, Inc.

Luck, David J and Rubin, R S. 1992. *Marketing Research*. 7th edn. New Delhi: Prentice Hall of India Ltd.

UNIT 13 RESEARCH REPORT WRITING

NOTES

Structure

13.0 INTRODUCTION

In the previous units, we have discussed and learnt about data collection and processing. On completion of the research study and after obtaining the research results, the real skill of the researcher lies in analysing and interpreting the findings and linking them with the propositions formulated in the form of research hypotheses at the beginning of the study. The statistical or qualitative summary of results would be little more than numbers or conclusions unless one is able to present the documented version of the research endeavour.

One cannot overemphasize the significance of a well-documented and structured research report. Just like all the other steps in the research process, this requires careful and sequential treatment. In this unit, we will be discussing in detail the documentation of the research study. The format and the steps might be moderately adjusted and altered based on the reader's requirement. Thus, it might be for an academic and theoretical purpose or might need to be clearly spelt and linked with the business manager's decision dilemma.

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13.1 OBJECTIVES

After going through this unit, you will be able to:

- Classify the various types of research reports
- Explain the process of report writing and presentation in business research
- Discuss the key features to be kept in mind in terms of the report format

13.2 TYPES OF RESEARCH REPORTS

The research report has a very important role to play in the entire research process. It is a concrete proof of the study that was undertaken. It is a one-way communication of the researcher's study and analysis to the reader/manager, and thus needs to be all-inclusive and yet neutral in its reporting. The significant role that a research report can play is as follows:

- The research report documents all the steps followed right from framing the research question to the interpretation of the study findings
- Each step also includes details on how and why that step was conducted, i.e. the justification for choosing one technique over the other.
- It also serves to authenticate the quality of the work carried out and establishes the strength of the findings obtained.
- The report gives a clear direction in terms of the implication of the results for the decision maker. This could be academic or applied depending on the orientation
- The report serves as a very important framework for anyone who would like to do research in the same area or topic.

13.2.1 Brief Reports

These kinds of reports are not formally structured and are generally short, sometimes not running more than four to five pages. The information provided has limited scope and is a prelude to the formal structured report that would subsequently follow. These reports could be designed in several ways.

- ***Working papers*** or ***basic reports*** are written for the purpose of recording the process carried out in terms of scope and framework of the study, the methodology followed and instrument designed. The results and findings would also be recorded here. However, the interpretation of the findings and study background might be missing, as the focus is more on the present study rather than past literature.
- ***Survey reports*** might or might not have an academic orientation. The focus here is to present findings in easy-to-comprehend format that includes figures

and tables. The advantage of these reports is that they are simple and easy to understand and present the findings in a clear and usable format.

13.2.2 Detailed reports

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These are more formal and could be academic, technical or business reports.

- **Technical reports:** These are major documents and would include all elements of the basic report, as well as the interpretations and conclusions, as related to the obtained results. This would have a complete problem background and any additional past data/records that are essential for understanding and interpreting the study results. All sources of data, sampling plan, data collection instrument(s), data analysis outputs would be formally and sequentially documented.
- **Business reports:** These reports include conclusions as understood by the business manager. The tables, figures and numbers of the first report would now be pictorially shown as bar charts and graphs and the reporting tone would be more in business terms. Tabular data might be attached in the appendix.

Check Your Progress

1. Name the type of report whose focus is more on the present study rather than past literature.
2. Do survey reports always have an academic orientation?

13.3 REPORT WRITING: STRUCTURE OF THE RESEARCH REPORT

Whatever the type of report, the reporting requires a structured format and by and large, the process is standardized. The major difference amongst the types of reports is that all the elements that make a research report would be present only in a detailed technical report in comparison to management report. Usage of theoretical and technical jargon would be higher in the technical report and visual presentation of data would be higher in the management report.

The process of report formulation and presentation is presented in Figure 13.1. As can be observed, the preliminary section includes the title page, followed by the letter of authorization, acknowledgements, executive summary and the table of contents. Then come the background section, which includes the problem statement, introduction, study background, scope and objectives of the study and the review of literature (depends on the purpose). This is followed by the methodology section, which, as stated earlier, is again specific to the technical report. This is followed by the findings section and then come the conclusions. The technical report would have a detailed bibliography at the end.

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In the management report, the sequencing of the report might be reversed to suit the needs of the decision-maker, as here the reader needs to review and absorb the findings. Thus, the last section on interpretation of findings would be presented immediately after the study objectives and a short reporting on methodology could be presented in the appendix.

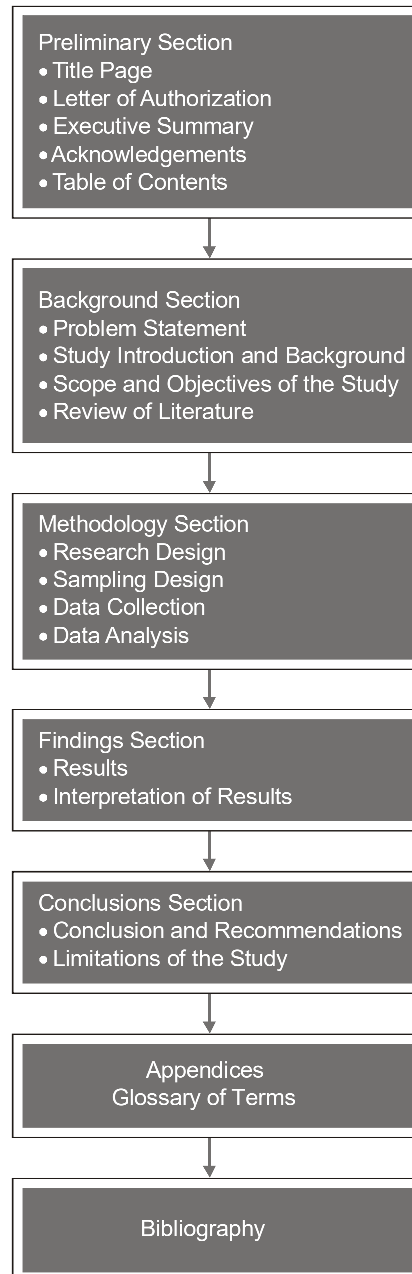


Fig. 13.1 *The Process of Report Formulation and Writing*

As presented in Figure 13.1, most research reports include the following sections:

13.3.1 Preliminary Section

This section mainly consists of identification information for the study conducted. It has the following individual elements:

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Title page: The title should be crisp and indicative of the nature of the project, as illustrated in the following examples.

Comparative analysis of BPO workers and schoolteachers with reference to their work–life balance

Segmentation analysis of luxury apartment buyers in the National Capital Region (NCR)

Letter of transmittal: This is the letter that broadly refers to the purpose behind the study. The tone in this note can be slightly informal and indicative of the rapport between the client-reader and the researcher. A sample letter of transmittal is presented in Exhibit 13.1. The letter broadly refers to three issues. It indicates the term of the study or objectives; next it goes on to broadly give an indication of the process carried out to conduct the study and the implications of the findings. The conclusions generally are indicative of the researcher's learning from the study.

Exhibit 1

Sample Letter of Transmittal

To:	Mr Prem Parashar	**From:**	Nayan Navre
Company:	Just Bondas Corporation (JBC)	**Company:**	Jigyasa Associates
Location:	Mumbai 116879	**Location:**	Sabarmati Dham, Mumbai
Telephone:	8786767; 4876768	**Telephone:**	41765888
Fax:	48786799	**Fax:**	41765899

Addendums: Highlight of findings (pages: 20)

15 January 2012

Dear Prem,

Please find the enclosed document which covers a summary of the findings of the November- December 2011 study of the new product offering and its acceptibility. I would be sending three hard copies of the same tomorrow.

Once the core group has discussed the direction of the expected results I would request you to kindly get back with your comments/queries/suggestions, so that they can be incorporated in the preparation of the final report document.

The major findings of the study were that the response of the non-vegetarians consuming the new *keema bonda pav* at Just Bondas was positive. As you can observe, however, the introduction of the non-vegetarian *bonda* has not been well received by the regular customers who visit the outlets for their regular *alloo bonda*. These findings, though on a small respondent base, are significant as they could be an indication of a deflecting loyal customer base.

Best regards,

Nayan

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Letter of authorization: The author of this letter is the business manager who formally gives the permission for executing the project. The tone of this letter, unlike the above document, is very precise and formal.

Table of contents: All reports should have a section that clearly indicates the division of the report based on the formal areas of the study as indicated in the research structure. The major divisions and subdivisions of the study, along with their starting page numbers, should be presented. Once the major sections of the report are listed, the list of tables come next, followed by the list of figures and graphs, exhibits (if any) and finally the list of appendices.

Executive summary: The summary of the entire report, starting from the scope and objectives of the study to the methodology employed and the results obtained, has to be presented in a brief and concise manner. The executive summary essentially can be divided into four or five sections. It begins with the study background, scope and objectives of the study, followed by the execution, including the sample details and methodology of the study. Next comes the findings and results obtained. The fourth section covers the conclusions and finally, the last section includes recommendations and suggestions.

Acknowledgements: A small note acknowledging the contribution of the respondents, the corporates and the experts who provided inputs for accomplishing the study is included here.

13.3.2 Main Report

This is the most significant and academically robust part of the report.

Problem definition: This section begins with the formal definition of the research problem.

Study background: Study background essentially begins by presenting the decision-makers' problem and then moves on to a description of the theoretical and contemporary market data that laid the foundation that guided the research.

In case the study is an academic research, there is a separate section devoted to the review of related literature, which presents a detailed reporting of work done on the same or related topic of interest.

Study scope and objectives: The logical arguments then conclude in the form of definite statements related to the purpose of the study. In case the study is causal in nature, the formulated hypotheses are presented here as well.

Methodology of research: The section would essentially have five to six sections specifying the details of how the research was conducted. These would essentially be:

- **Research framework or design:** The variables and concepts being investigated are clearly defined, with a clear reference to the relationship being studied. The justification for using a particular design also has to be presented here.

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- **Sampling design:** The entire sampling plan in terms of the population being studied, along with the reasons for collecting the study-related information from the given group is given here.
- **Data collection methods:** In this section, the researcher should clearly list the information needed for the study as drawn from the study objectives stated earlier. The secondary data sources considered and the primary instrument designed for the specific study are discussed here. However, the final draft of the measuring instrument can be included in the appendix.
- **Data analysis:** The assumptions and constraints of the analysis need to be explained here in simple, non-technical terms.
- **Study results and findings:** This is the most critical chapter of the report and requires special care; it is probably also one of the longest chapters in the document.

13.3.3 Interpretations of Results and Suggested Rcommendations

This section comes after the main report and contains interpretations of results and suggested recommendations. It presents the information in a summarized and numerical form.

Sometimes, the research results obtained may not be in the direction as found by earlier researchers. Here, the skill of the researcher in justifying the obtained direction is based on his/her individual opinion and expertise in the area of study. After the interpretation of results, sometimes, the study requirement might be to formulate indicative recommendations to the decision-makers as well. Thus, in case the report includes recommendations, they should be realistic, workable and topically related to the industry studied.

Limitations of the study

The last part in this section is a brief discussion of the problems encountered during the study and the constraints in terms of time, financial or human resources.

End notes

The final section of the report provides all the supportive material in the study. Some of the common details presented in this section are as follows:

Appendices: The appendix section follows the main body of the report and essentially consists of two kinds of information:

1. Secondary information like long articles or in case the study uses/is based on/refers to some technical information that needs to be understood by the reader; long tables or articles or legal or policy documents.
2. Primary data that can be compressed and presented in the main body of the report. This includes original questionnaire, discussion guides, formula

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used for the study, sample details, original data, long tables and graphs which can be described in statement form in the text.

Bibliography: This is an important part of the final section as it provides the complete details of the information sources and papers cited in a standardized format. It is recommended to follow the publication manuals from the American Psychological Association (APA) or the Harvard method of citation for preparing this section.The reporting content of the bibliography could also be in terms of:

- **Selected bibliography:** Selective references are cited in terms of relevance and reader requirement. Thus, the books or journals that are technical and not really needed to understand the study outcomes are not reported.
- **Complete bibliography:** All the items that have been referred to, even when not cited in the text, are given here.
- **Annotated bibliography:** Along with the complete details of the cited work, some brief information about the nature of information sought from the article is given.

At this juncture we would like to refer to citation in the form of a footnote. To explain the difference we would first like to explain what a typical footnote is:

Footnote: A typical footnote, as the name indicates, is part of the main report and comes at the bottom of a page or at the end of the main text. This could refer to a source that the author has referred to or it may be an explanation of a particular concept referred to in the text.

The referencing protocol of a footnote and bibliography is different. In a footnote, one gives the first name of the person first and the surname next. However, this order is reversed in the bibliography. Here we start first with the surname and then the first name. In a bibliography, we generally mention the page numbers of the article or the total pages in the book. However, in a footnote, the specific page from which the information is cited is mentioned. A bibliography is generally arranged alphabetically depending on the author's name, but in the footnote the reporting is based on the sequence in which they occur in the text.

Glossary of terms: In case there are specific terms and technical jargon used in the report, the researcher should consider putting a glossary in the form of a word list of terms used in the study. This section is usually the last section of the report.

Check Your Progress

3. Name the section which includes the title page, followed by the letter of authorization, acknowledgements, executive summary and the table of contents.
4. What does the annotated bibliography include?

13.4 REPORT WRITING: FORMULATION RULES FOR WRITING THE REPORT

NOTES

Listed below are some features of a good research study that should be kept in mind while documenting and preparing the report.

- **Clear report mandate:** While writing the research problem statement and study background, the writer needs to be absolutely clear in terms of why and how the problem was formulated.
- **Clearly designed methodology:** Any research study has its unique orientation and scope and thus has a specific and customized research design, sampling and data collection plan. In researches, that are not completely transparent on the set of procedures, one cannot be absolutely confident of the findings and resulting conclusions.
- **Clear representation of findings: C**omplete honesty and transparency in stating the treatment of data and editing of missing or contrary data is extremely critical.
- **Representativeness of study finding:** A good research report is also explicit in terms of extent and scope of the results obtained, and in terms of the applicability of findings.

Thus, some guidelines should be kept in mind while writing the report.

- **Command over the medium:** A correct and effective language of communication is critical in putting ideas and objectives in the vernacular of the reader/decision-maker.
- **Phrasing protocol:** There is a debate about whether or not one makes use of personal pronoun while reporting. The use of personal pronoun such as 'I think…..' or 'in my opinion…..' lends a subjectivity and personalization of judgement. Thus, the tone of the reporting should be neutral. For example:

'Given the nature of the forecasted growth and the opinion of the respondents, it is likely that the……'

Whenever the writer is reproducing the verbatim information from another document or comment of an expert or published source, it must be in inverted commas or italics and the author or source should be duly acknowledged. For example:

Sarah Churchman, Head of Diversity, PricewaterhouseCoopers, states 'At PricewaterhouseCoopers we firmly believe that promoting work–life balance is a

'business-critical' issue and not simply the 'right thing to do'.The writer should avoid long sentences and break up the information in clear chunks, so that the reader can process it with ease.

Simplicity of approach: Along with grammatically and structurally correct language, care must be taken to avoid technical jargon as far as possible. In case it is important to use certain terminology, then, definition of these terms can be provided in the glossary of terms at the end of the report.

Report formatting and presentation: In terms of paper quality, page margins and font style and size, a professional standard should be maintained. The font style must be uniform throughout the report. The topics, subtopics, headings and subheadings must be construed in the same manner throughout the report. The researcher can provide data relief and variation by adequately supplementing the text with graphs and figures.

13.4.1 Guidelines for Presenting Tabular Data

Most research studies involve some form of numerical data, and even though one can discuss this in text, it is best represented in tabular form. The data can be given in simple summary tables, which only contain limited information and yet, are, essentially critical to the report text.

The mechanics of creating a summary table are very simple and are illustrated below with an example in Table 13.1. The illustration has been labelled with numbers which relate to the relevant section.

Table identification details: The table must have a title (1a) and an identification number (1b). The table title should be short and usually would not include any verbs or articles. It only refers to the population or parameter being studied. The title should be briefly yet clearly descriptive of the information provided. The numbering of tables is usually in a series and generally one makes use of Hindu Arabic numbers to identify them.

Data arrays: The arrangement of data in a table is usually done in an ascending manner. This could either be in terms of time, as shown in Table 13.1 (column-wise) or according to sectors or categories (row-wise) or locations, e.g., north, south, east, west and central. Sometimes, when the data is voluminous, it is recommended that one goes alphabetically, e.g., country or state data. Sometimes there may be subcategories to the main categories, for example, under the total sales data—a columnwise component of the revenue statement—there could be subcategories of department store, chemists and druggists, mass merchandisers and others. Then these have to be displayed under the sales data head, after giving a tab command as follows:

Table 13.1 *Automobile Domestic Sales Trends*

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Category	Yearwise data (number of cars)				
	2002-2003	2003-2004	2004-2005	2006-2007	2007-2008
Passenger vehicles……	707,198	902,096	1,061,572	1,143,076	1,379,979
Commercial Vehicles……	190,682	260,114	318,430	351,041	467,765
Three-wheelers……	231,529	284,078	307,862	359,920	403,910
Two-wheelers……	4,812,126	5,364,249	6,209,765	7,052,391	7,872,334
Grand Total*	5,941,535	6,810,537	7,897,629	8,906,428	10,123,988

*Does not include second hand car sales.

Source: SIAM

(Callout labels in the figure: 1a, 1b, 2a, 2b, 3, 4a, 4b, 4c, 5b, 6a, 7a)

Total sales

Mass market

Department store

Drug stores

Others (including *paan beedi* outlets)

Measurement unit: The unit in which the parameter or information is presented should be clearly mentioned.

Spaces, leaders and rulings (SLR): For limited data, the table need not be divided using grid lines or rulings, simple white spaces add to the clarity of information presented and processed. In case the number of parameters are too many, it is advisable to use vertical ruling. Horizontal lines are drawn to separate the headings from the main data, as can be seen in Table 13.1. When there are a number of subheadings as in the sales data example, one may consider using leaders (…….) to assist the eye in reading the data.

Total sales

Mass market………

Department store………

Drug stores………

Others (including *paan beedi* outlets)………

Assumptions, details and comments: Any clarification or assumption made, or a special definition required to understand the data, or formula used to arrive at a particular figure, e.g., total market sale or total market size can be given after the main tabled data in the form of footnotes.

Data sources: In case the information documented and tabled is secondary in nature, complete reference of the source must be cited after the footnote, if any.

Special mention: In case some figure or information is significant and the reader should pay special attention to it, the number or figure can be bold or can be highlighted to increase focus.

13.4.2 Guidelines for Visual Representations: Graphs

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Similar to the summarized and succinct data in the form of tables, the data can also be presented through visual representations in the form of graphs.

Line and curve graphs: Usually, when the objective is to demonstrate trends and some sort of pattern in the data, a line chart is the best option available to the researcher. It is also possible to show patterns of growth of different sectors or industries in the same time period or to compare the change in the studied variable across different organizations or brands in the same industry. Certain points to be kept in mind while formulating line charts include:

- The time units or the causal variable being studied are to be put on the X-axis, or the horizontal axis.
- If the intention is to compare different series on the same chart, the lines should be of different colours or forms (Figure 13.2).

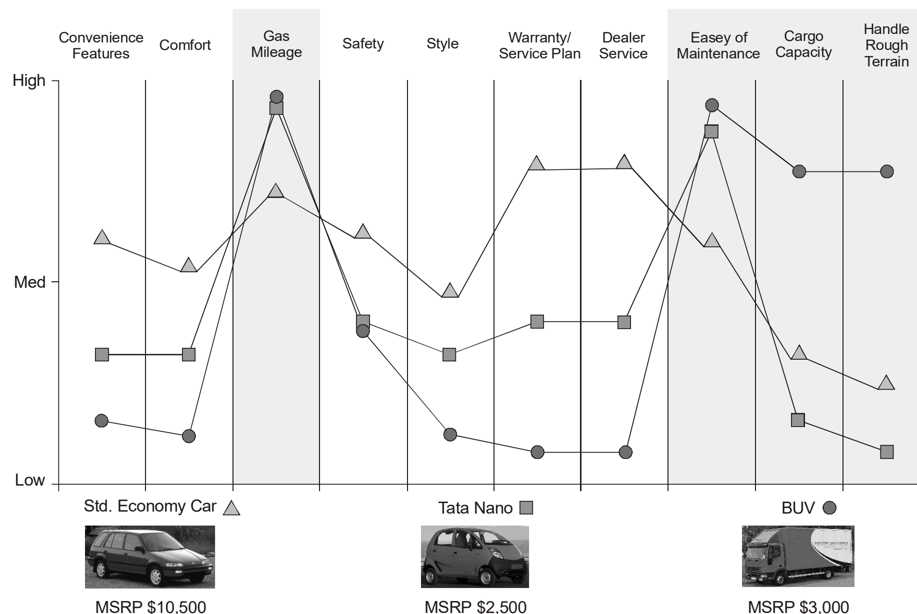


Fig. 13.2 *Comparative Analysis of Vehicles (including Nano) on Features Desired by Consumers*

- Too many lines are not advisable; an ideal number would be five or less than five lines on the chart.
- The researcher also must take care to formulate the zero baseline in the chart as otherwise, the data would seem to be misleading. For example, in Figure 13.3a, in case the zero baseline is (as shown in the chart) the expected change in the number of hearing aids units to be sold over the time period

2002–03 to 2007–08, it can be accurately understood. However, in Figure 13.3b, where the zero is at 1,50,000 units, the rate of growth can be misjudged to be more swift.

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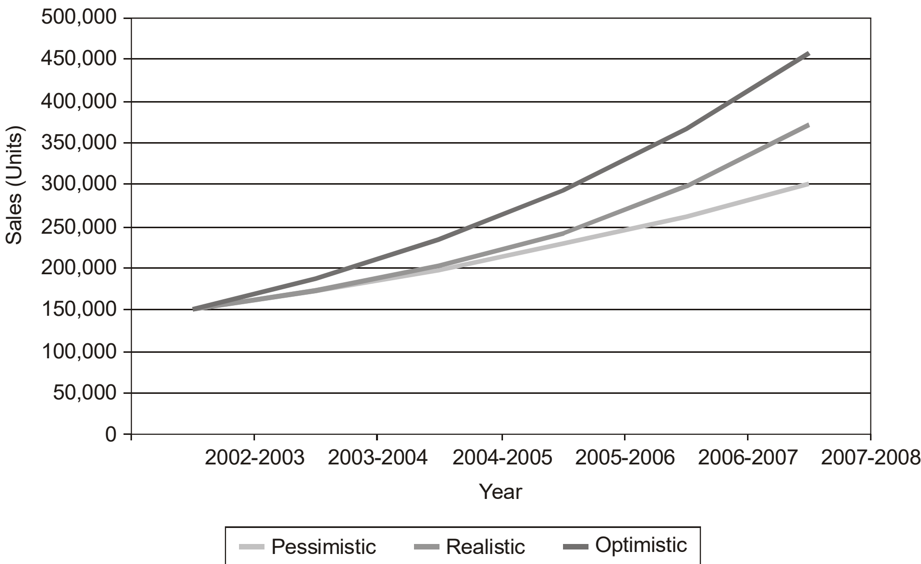


Fig. 13.3(a) *Expected Growth in the Number of Hearing Aids Units to be Sold in North India (three perspectives)*

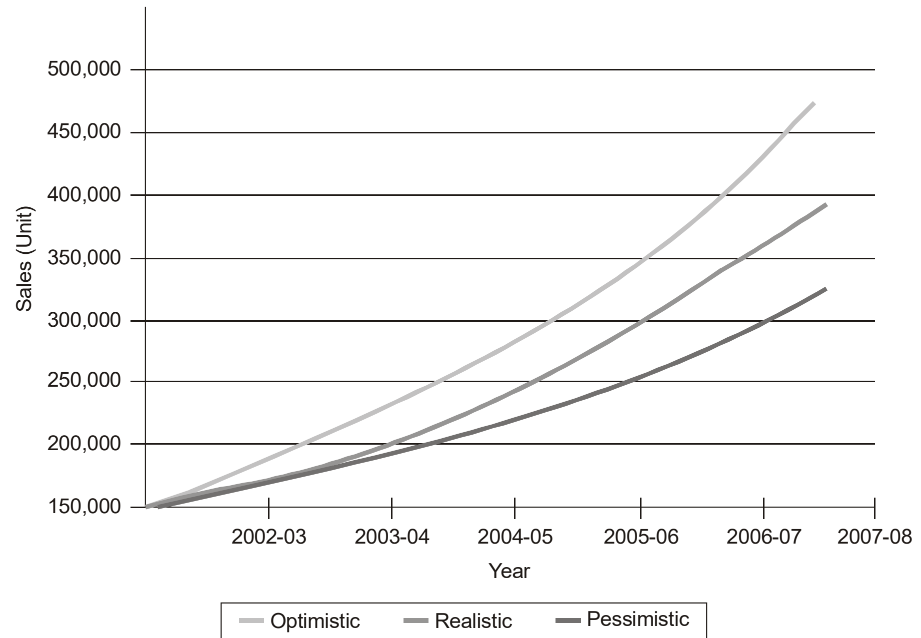


Fig. 13.3(b) *Expected Growth in the Number of Hearing Aids Units to be Sold in North India (three perspectives)*

Area or stratum charts: Area charts are like the line charts, usually used to demonstrate changes in a pattern over a period of time. What is done is that the change in each of the components is individually shown on the same chart and

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each of them is stacked one on top of the other. The areas between the various lines indicate the scale or volume of the relevant factors/categories (Figure 13.4).

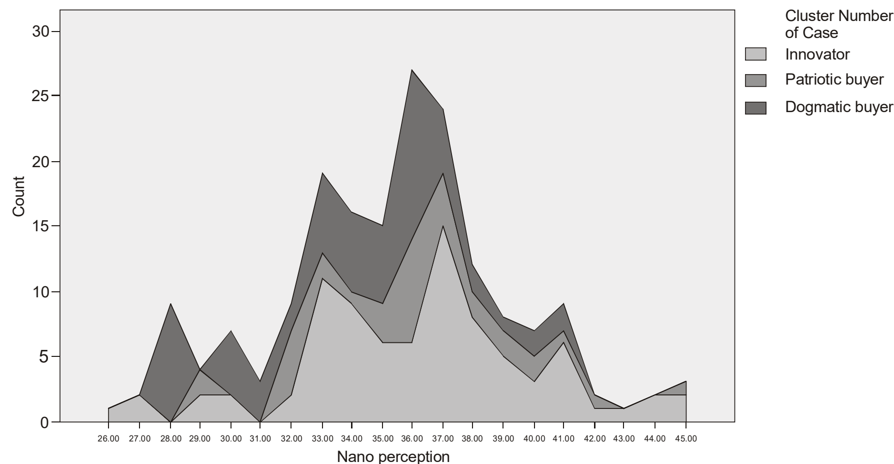


Fig. 13.4 *Perception of Nano by Three Psychographic Segments of Two-wheeler Owners*

Pie charts: Another way of demonstrating the area or stratum or sectional representation is through the pie charts. The critical difference between a line and pie chart is that the pie chart cannot show changes over time. It simply shows the cross-section of a single time period**.** There are certain rules that the researcher should keep in mind while creating pie charts.

- The complete data must be shown as a 100 per cent area of the subject being graphed.
- It is a good idea to have the percentages displayed within or above the pie rather than in the legend as then it is easier to understand the magnitude of the section in comparison to the total. For example,

Figure 13.5 shows the brand-wise sales in units for the sample of existing brands of hearing aids in the North Indian market.

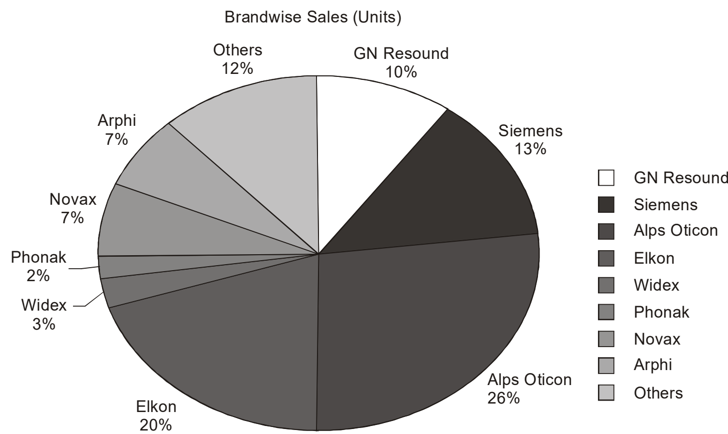


Fig. 13.5 *Brandwise Sales (units) of Hearing Aids in the North Indian Market (2002–03)*

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- Showing changes over time is difficult through a pie chart, as stated earlier. However, the change in the components at different time periods could be demonstrated as in Figure 13.6, showing a sample share of the car market in India in 2009 and the expected market composition of 2015.

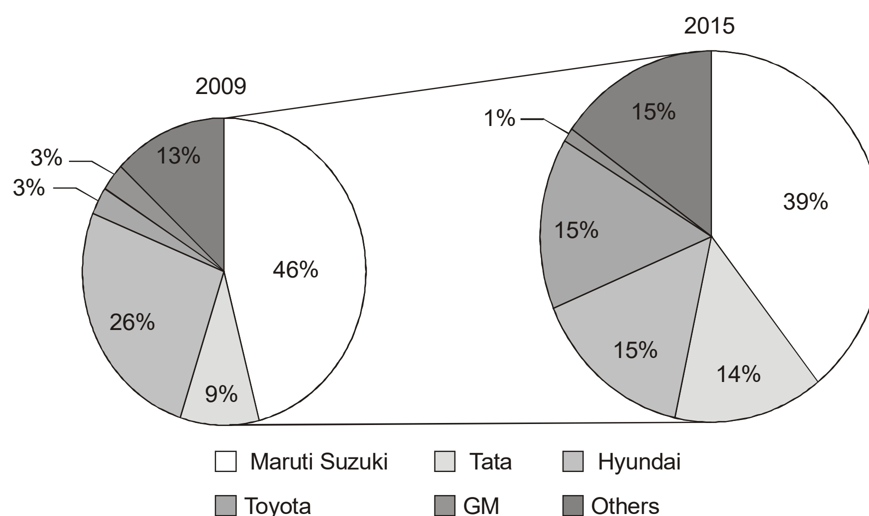


Fig. 13.6 *Sample Structure of the Indian Car Market (2009) and the Forecasted Structure for 2015*

Bar charts and histograms: A very useful representation of quantum or magnitude of different objects on the same parameter are bar diagrams. The comparative position of objects becomes very clear. The usual practice is to formulate vertical bars; however, it is possible to use horizontal bars as well if none of the variable is time related [Figure 13.7(a)]. Horizontal bars are especially useful when one is showing both positive and negative patterns on the same graph [Figure 13.7(b)]. These are called bilateral bar charts and are especially useful to highlight the objects or sectors showing a varied pattern on the studied parameter.

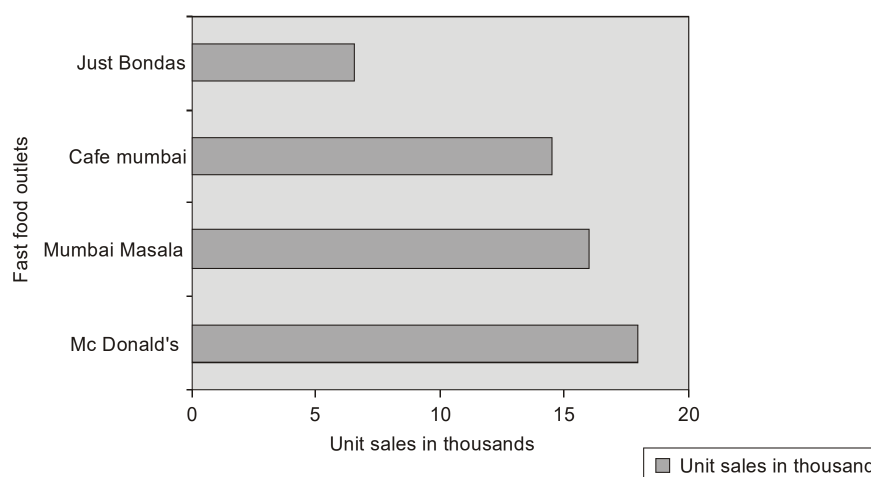


Fig. 13.7(a) *Bar Chart per Day, Unit Sales (thousands) at Fast Food Outlets in Mumbai*

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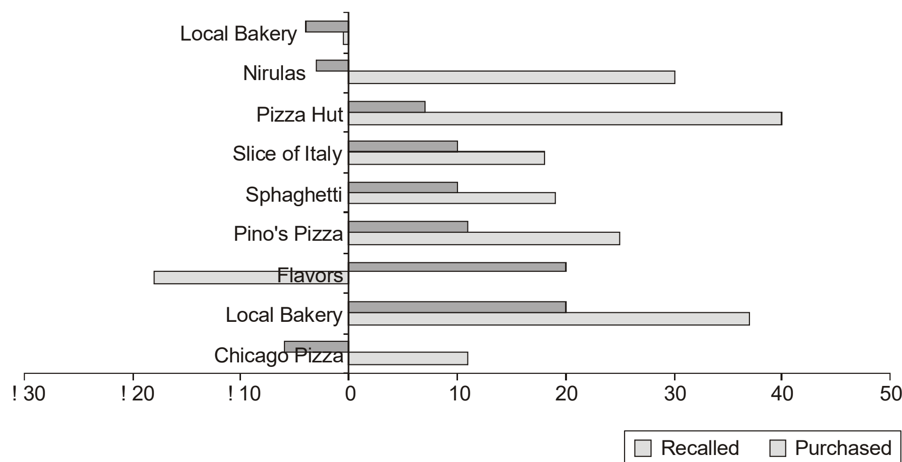


Fig. 13.7(b) Bilateral Bar Chart—the Brand Recall and Brand Purchase Response for Pizza Joints in the NCR

Another variation of the bar chart is the histogram (Figure 13.8) here the bars are vertical and the height of each bar reflects the relative or cumulative frequency of that particular variable.

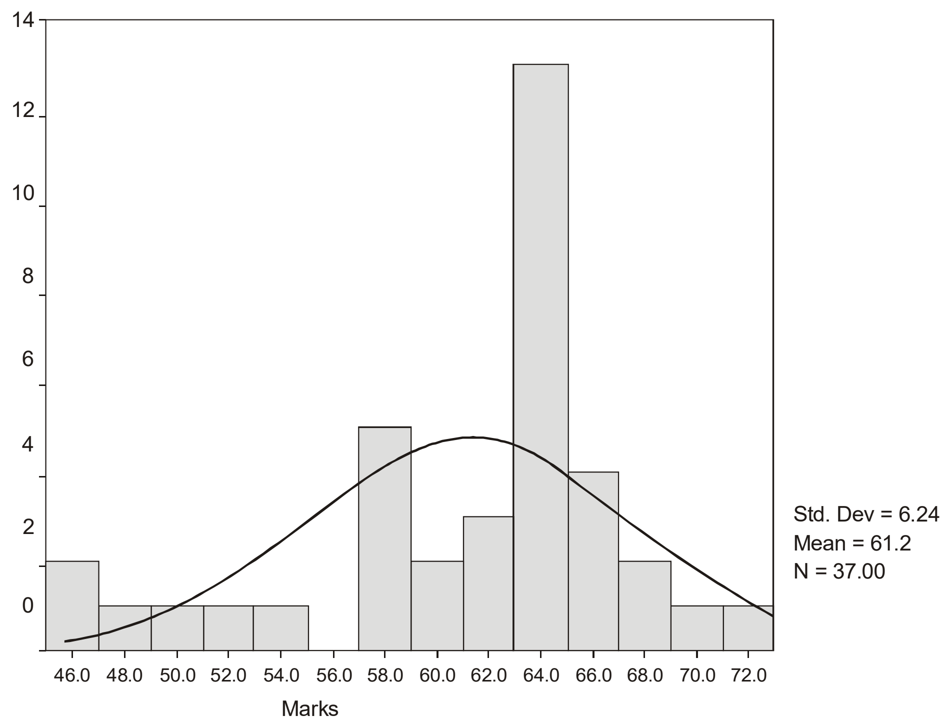


Fig. 13.8 Histogram (with normal curve) Displaying Marks in a Course on Research Methods for Management

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Check Your Progress

5. What is the best option available to the researcher when the objective is to demonstrate trends and some sort of pattern in the data?
6. State the ideal number of lines in a chart.
7. Mention the things a pie chart cannot show.

13.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Working papers or basic reports are the type of report whose focus is more on the present study rather than past literature.
2. No, the survey reports might or might not have an academic orientation.
3. The preliminary section is the section which includes the title page, followed by the letter of authorization, acknowledgements, executive summary and the table of contents.
4. The annotated bibliography contains complete details of the cited work, along with some brief information about the nature of information sought from the article.
5. Line chart is the best option available to the researcher when the objective is to demonstrate trends and some sort of pattern in the data.
6. The ideal number of lines in a chart is five or less.
7. The pie chart cannot show changes over time, as it simply shows the cross-section of a single time period.

13.6 SUMMARY

- The most important task ahead of the researcher is to document the entire work done in the form of a well structured research report.
- The orientation and structure of the report will depend on what kind of report is being constructed. These could be brief or detailed; academic, technical or business report.
- The, reports generally follow a standardized structure. The entire report can be divided into three main sections—the preliminary section, the main body and endnotes.

- There must be no ambiguity in either presenting the findings or representativeness of the findings.
- Visual relief for the written can be provided through figures, tables and graphs.

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13.7 KEY WORDS

- **Annotated bibliography:** A bibliography that includes brief explanations or notes for each reference.
- **Bibliography:** A list of the works of a specific author or publisher.
- **Executive summary:** The summary of the entire report, starting from the scope and objectives of the study to the methodology employed and the results obtained, presented in a brief and concise manner.
- **Letter of transmittal:** The letter that broadly refers to the purpose behind the study.
- **Working paper:** Report that is written for the purpose of recording the process carried out in terms of scope and framework of the study, the methodology followed and instrument designed.

13.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What should be the ideal structure of a research report? What are the elements of the structure defined by you?
2. What are the guidelines a researcher must follow for tabular representation of the research results?
3. Differentiate between the referencing protocol of a footnote and bibliography.
4. How is a technical report different from a management report?

Long-Answer Questions

1. What are the different kind of reports available to the researcher? Do the criteria become different for different kinds of reports? Explain with examples.
2. What are the guidelines for effective report writing? Illustrate with suitable examples.
3. Discuss the guidelines for graphical representations of data in reports. What are the audio-visual aids available for the purpose?

13.9 FURTHER READINGS

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Chawla D and Sondhi N. 2016. *Research Methodology: Concepts and Cases*, 2nd edition. New Delhi: Vikas Publishing House.

Easterby-Smith, M, Thorpe, R and Lowe, A. 2002. *Management Research: An Introduction,* 2nd edn. London: Sage.

Grinnell, Richard Jr (ed.). 1993. *Social Work, Research and Evaluation* 4th edn. Itasca, Illinois: F E Peacock Publishers.

Kerlinger, Fred N. 1986. *Foundations of Behavioural Research*, 3rd edn. New York: Holt, Rinehart and Winston.

UNIT 14 ETHICS IN RESEARCH

NOTES

Structure

14.0 INTRODUCTION

In the earlier units, we have understood the process of research as it exists in the business world. However, one needs to be clear that like every other aspect of the working environment, the research process also has to be guided and monitored by a code of ethics. This becomes important when we see that research requires us to collect information and may be at times conduct experimentation also to test the study hypotheses. Thus it becomes important for the researcher to be absolutely ethical and transparent in conducting the study. He also needs to ensure that no physical or mental harm is caused to the study respondents. And lastly, in case he is conducting the research for a business manager he must maintain the confidence of the client and not reveal the study findings and approach in case the client does not want this to be public.

Thus, in this unit we will learn about how we must conduct ourselves when we carry out a research study. This involves a code of ethics as related to the client as well as the researcher and the respondents.

14.1 OBJECTIVES

After going through this unit, you will be able to:

- Explain the role of ethics in business research
- Describe the ethical standards that the client must follow

- Discuss the ethical responsibilities of the researcher
- Explain how to protect the rights of the respondent
- Describe the ethical principles to be followed in the overall research process

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14.2 MEANING OF RESEARCH ETHICS

Ethical standards are extremely important no matter what be the field of study. This takes a special meaning in the conduction of research. Rowley (2004) has put it very simply as 'conducting research ethically is concerned with respecting privacy and confidentiality, and being transparent in the use of research data. Ethical practices hinge on respect and trust and approaches that seek to build rather than demolish relationships.' Russeft et al. (1999) advocated that while conducting business research, the approach must be professional and responsible, the data collection must be attempted with the respondent's consent under appropriate and ethically correct methods; and, last but not the least, the interpretation has to be done in a careful unbiased manner.

A number of corporations have developed their own code of ethics regarding the conduct of research. While this practice of defining business ethics, which includes research ethics, is common in most organizations in the West, in India this is spelt out and documented in the pharmaceutical sector and some banks like HSBC. Besides this, there are also well established and detailed ethical guidelines available from international bodies, for example, the Social Research Association's (SRA's) ethical guidelines, the American Psychological Association (APA) code of ethics, code of standards and ethics for survey research designed by the Council of American Survey Research Organizations (CASRO), American Marketing Association (AMA) and Business Marketing Association (BMA) code of conduct and ethics.

To understand the code of ethics involved in research, one needs to understand the three significant stakeholders involved in any research, namely:

- The sponsoring clients or decision-makers.
- The respondents from whom one seeks the information.
- The researcher himself/herself while administering and compiling the study.

Each one of these entities has their own specific interests and needs and, thus, the ethical concerns regarding each one would be unique. Thus, the following sections present brief guidelines on the ethical issues and their management.

14.2.1 Client's Ethical Code

Similar to any other business transaction, research is also an exchange process between various people. The first of these is the one between the sponsoring client and the investigator. Thus both parties have an ethical obligation towards the other. In case the study is being conducted for a business client, complete

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transparency in terms of data gathering and interpreting is a must. It has been observed that the client might be a business manager who because of his own personal interests might steer the results in a specific direction in order to fulfil a hidden agenda. For example, in case a warehousing organization is looking at business expansion and hires a research agency to conduct a research study in order to provide directions.It might so happen that the business manager from the client side, who is dealing with the research agency owns a transport fleet and thus wants the researcher to recommend courier and transit warehousing services as business opportunities that the company can go into.

It has been commonly found amongst small and relatively younger firms to ask for proposals from research agencies for the conduct of a study. However, once they obtain the details of the intended methodology, they usually get the study conducted by their own team or by trainees at a low to minimal cost to the company. And since the proposals are the first stage of a research bid, the company is under no obligation to pay for the research methodology collected by them in an underhand manner.

Another instance could be that even though the initial exploratory research and literature review indicate the nature of the respondent population, the client might, based on his own notions, force the researcher to undertake the study on a specific population. For example, if a new technology is being introduced in the company and the use requires computer literacy, the client might ask the researcher to measure the acceptability of the product amongst only the computer-savvy population. Thus the results would automatically be bent towards acceptance.

Sometimes, the interpretation and recommendations might be beyond the scope of a study. For example, in the organic food study, which was conducted amongst retailers and consumers, the client might ask the researcher to suggest strategies for educating and building usage and recommendations amongst dieticians and doctors.

It is recommended in this instance that the researcher must conduct a comprehensive exploratory research and develop clearly stated objectives that do not leave any scope for unethical intervention. Secondly, he must tell business manager that unless the results are unbiased the study will not contribute to informed decision making. In case of an unethical manager or client, it is best to avoid making recommendations and formulating strategies and leave the use or non-use of the data to the manager. And if nothing works it is best to terminate the research study, as unethical reporting and compilation is bound to spoil the researcher’s reputations.

14.2.2 Researcher’s Ethical Code

Since the researcher is the most involved and main person responsible for the study, it is very important that the highest ethical standards be maintained by him. Some specific checks he can look at are as follows:

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Quality control

A very important consideration, both short-term and long-term, is to maintain the standards of quality in the conduct of the study. The researcher must be absolutely objective and correct in choosing the research design that would be right for the study. For example, for studying the impact of a mathematics study programme on an experimental group of children, the researcher must have a matched control group of children with a similar understanding of mathematics so that the comparison is correct.

Sometimes, the client might be unaware of the analytical rules and conditions for the result to be valid, thus it is the responsibility of the researcher to be absolutely transparent about the significance of the results obtained and refrain from emphasizing findings that might be of very little strength or value.

Privacy control

The most significant and important ethical concern of a research study is the issue of trust and confidentiality. At no cost must the researcher reveal any aspect of the study without the consent of the client. This could be in terms of not revealing the name of the company. For example, if the client is interested in finding out the comparative standing of their product with the competitor's product, it becomes critical to conduct the study amongst users of the product category rather than only the company brand in order to get an unbiased evaluation.

The researcher might also need to guard the reason or purpose of the study. For example if the client wants to measure a new product potential, then revealing the reason for the study might lead to the concept or idea being adopted and converted into a product prototype by someone else before the client is out with the offering. The third level of confidentiality that the researcher must ensure is the complete confidentiality of the findings till the research outcome has been converted into a business decision. For example, based on the organizational health index of its workers and the attrition rate, the correlation between the two variables might be alarming enough to require a major restructuring of the existing employee benefits and work policy. Or the research study might involve a comprehensive and detailed study of potential candidates being considered for the role of the CEO, as the existing leader is due for retirement. Thus, revelation of the findings of such research might lead to turbulence and divided opinion in the organization. Thus the results should not be made available to all till they have been brought into action.

Check Your Progress

1. List some of the international bodies which have provided well established and detailed ethical guidelines.
2. State the most significant and important ethical concern of a research study.
3. Mention the controls which are important checks in a study.

14.3 ETHICAL CODES RELATED TO RESPONDENTS

The most important and vulnerable person in the research study is the respondent from whom the data is to be collected. Every association and organization that is directly or indirectly involved with research has made clear and detailed guidelines for ensuring that unethical treatment of the respondent does not happen.

The American Association for Public Opinion Research has formulated the following code of ethics for survey researchers, with reference to the respondent:

- We shall strive to avoid the use of practices or methods that may harm, humiliate or seriously mislead survey respondents.
- Unless the respondent waives confidentiality for specific uses, we shall hold as privileged and confidential all information that might identify a respondent with his or her responses. We shall also not disclose or use the names of respondents for non-research purposes unless the respondent grants us permission to do so.

Study disclosure

The researcher needs to have complete and transparent information regarding the purpose of collecting data and what sort of information would be required from the respondent. The person must know what kind of questioning would be done, so that he is able to understand what the researcher is looking for and whether he has the information, whether he wants to share all or part of it and also how much time and effort would be needed. For example, for a new concept test or a segmentation analysis or an organizational climate survey the administration would require considerable time and commitment from the respondent. Secondly, if it is a before-and-after product acceptability or usage study, again the person would be contacted twice to assess the experience.Thus the researcher needs to be absolutely truthful about the nature and objectives of the study.

Coercion and influence

The researcher should not at any stage, either before or during the data collection stage, try to pressurize the respondent through persuasive influence or by forcing him to share information. For example, if the respondent has been through some traumatic experience, he/she might not want to share all details with a stranger, even if it is for an objective study. Schinke and Gilchrist (1993) state that under standards set by the National Commission for the protection of human subjects, all informed-consent procedures must meet three criteria:

- Participants must be competent to give consent
- Sufficient information must be provided to allow for a reasonable decision
- Consent must be voluntary and uncoerced

Sometimes, it may so happen that the respondent is too young or too old or not literate and thus, unable to understand when the researcher might be either leading him/her to give certain preset answers or trying to force the person to share information that he does not want to reveal or which once shared might be misinterpreted.

Sensitivity and respect

There are certain issues like shoplifting or sexual orientation, which are not topics that can be managed in a structured, impersonal manner. The researcher should devote more time here and also keep the questions more open-ended, and usually such situations need a considerable rapport formation and a non-threatening atmosphere. The researcher, at all times, would need to treat the respondent with due respect and be transparent about the nature and objective of the questioning.

Experimentation and implication

In case the respondent is going to be part of the experimental group subjected to any sort of treatment, for example, a new shampoo trial or an intervention programme that may involve some behavioural change, complete information must be given regarding the course of the experiment and any risk, even minimal, which might be involved. The researcher, thus, must ensure minimal risk to the respondent and should in no way cause any harm to the person, even if it is for the quest of knowledge. Bailey (1978) describes this 'harm' as not only hazardous or medical experiments but also any social research that might involve such things as discomfort, anxiety, harassment, invasion of privacy or demeaning or dehumanizing procedures.

Agreement or consent

Once the researcher has clearly communicated the purpose, the nature and likely outcome of the study, it is advisable to make a mutual written or unwritten contract. This ensures that there is no unpleasantness or legal confrontation on either side. Another advantage of this is that in case a point was not very clear the issue gets clarified. For example, for a personal care usage study, the consumer might be under the impression that a questionnaire on usage would be filled in when actually the researcher wants to observe/record the usage ritual. This might call for some invasion of privacy of the respondent by the researcher, and thus taking the consent beforehand would make things clear for both the parties.

Sometimes, the nature of the study might require that the name of the company be disguised. For example, one cannot start a study by saying, 'We are conducting a survey for Mother Dairy milk; which do you think is the best milk in the city?' Thus, here the debriefing about the company sponsoring the research can be revealed after the data has been collected, and the purpose of the disguise can be revealed. This ensures respondents' goodwill and cooperation.

14.4 RESPONSIBILITY OF ETHICS IN RESEARCH

Besides ensuring that specific protocols and codes be followed for the two benefactors (client) and contributors (respondents), there are some basic tenets that the researcher must not forego. These are significant not only for the body of knowledge that the researcher is contributing to but also for the society in which we exist.

Professional creed

We have already discussed this in detail in both the sections above. However, here for professional creed, we refer to the overall conduct of the researcher, who has to be truthful during all phases of the study, whether in the conceptualization, conduction or presentation of the research study.

- At no stage should the researcher exaggerate or underplay the expense or effort incurred in the conduct of the study. Thus, sometimes the investigator might overclaim the expense incurred in travel or field visit. On the other hand, he might underpay the field investigators that he has kept for data collection by hiring undergraduate students rather than professional investigators.
- The respondent group being studied should be a true representative of the identified respondent population studied and not a skewed and biased sample. Another unethical practice observed is that the researcher might conduct the study with a professional group of respondents who are well versed in the response technique and thus give 'good' or predictable answers.
- The data and the questionnaire completed should be on authentic, real-time conduction, with actual respondents representative of the population under study and not fake completion done by the field investigators themselves.
- The findings and results should be presented as they were found based on actual conduction and under no circumstances must the researcher attempt to fudge or manipulate the results of the study.

Professional confidentiality

The researcher must bear the responsibility to maintain the confidentiality of the research findings and not making public any aspects of the study, in an apparent or camouflaged manner. This code of ethics applies both to the sponsoring client, as well as the respondent. The anonymity and privacy of the respondent is to be respected and not violated. Also, recording private or personal behaviour with hidden devices is considered a monumental violation of an individual's right to privacy (e.g., observing people in a fitting room with a hidden camera).

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The right to privacy and confidentiality takes on a new meaning in cyberspace, where the respondent's personal and demographic details are made available to the researching company and this could be compiled and collated and sold as databases to various service providers as authentic locational details for tapping potential customers. Thus, maintaining anonymity and confidentiality of information shared is a professional norm that any ethical researcher should follow. In case the data is to be shared, it must be done with the consent of the respondent.

Professional objectivity

As a true researcher and contributor to the existing body of knowledge, the researcher must maintain the objectivity of an absolutely neutral reporter of facts. He must maintain objectivity in all phases of the study while:

- Designing the research objectives which must be based on facts and sound analysis rather than simple opinion.
- Collecting information by using a standard and not differential set of instructions. For example, in the intervention study quoted earlier, the researcher must give the instructions in the same way to both the experimental and control group and in no way try to exaggerate the actual impact of the treatment.
- Interpreting and presenting the findings as they are and not in a particular direction based on the researcher's own gut feel or liking. For example, a researcher who is a consumer of organic food will attempt to exaggerate the health benefits of the products not because that is what was found but because as a consumer of the category, that is what he believes.

Thus, as stated earlier, just like any other business function a code of ethics for conducting research is well structured and laid out by almost every business association. At all times, the researcher must remember that besides aiding in business decision-making, research also contributes to the huge domain of management knowledge. Thus, an authentic, transparent and objective reporting and compilation of the research becomes that much more critical.

Check Your Progress

4. Who is the most important and vulnerable person in the research study?
5. What is the benefit of a mutual written or unwritten contract?
6. What is professional creed in research?

14.5 USES OF LIBRARY AND INTERNET IN RESEARCH

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In this section, you will study the aspects of using library and internet in research.

14.5.1 Uses of Library in Research

It is common for a researcher to be confused and disoriented while using the library for research. Usually, this happens because the researchers feel at a loss as to where from and how to start searching the library resources. Therefore, a systematic and methodical approach towards the vast source of information that libraries usually offer is very essential. This can facilitate researchers in using quality time for conducting his/her search and collecting the essential information. Researchers should, therefore, create a concrete library research plan. Such a plan can enable him/her make an effective use of library materials for research.

Library Research Plan

A library research plan is a predefined activity that gives direction to your research. It is an act that involves evaluation that helps determine the subsequent activities to be followed by the researcher. As such, the research plan is a sequence of steps that the researcher should follow in order to get a comprehensible and reliable outline to adhere to. The various steps contained in a research plan can be stated as follows:

- **Subject evaluation**: This involves analysing the research subject with an informative perspective. The researcher should find out the extent of information that is already available and known to him/her. This can give a clear idea about the unknown information that needs to be searched in the library.
- **Determine the scope of research**: This involves identifying whether the research is a general study of occurrences or is concerned with more specific investigation. For example, whether your research is concerned with studying the eating habits of working women or eating habits of working people. Accordingly, you have to search for the relevant content. You should also check the chronological, geographical, political and other such aspects of your research study. You need to also analyse if your research deals with any specific locality, a particular time span or any current issue.
- **Sort-out keywords**: The research subject should be disintegrated into a set of key terms or key words. A key word can be defined as a term that expresses the most basic words of the research content, which describes your broad topic. The researcher should separate the distinct and unique

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words and important concepts contained in the research to use as subject key words. This will greatly help the researcher keep in track the related topics of the research subject and avoid deviation. It is thus the most significant activity of a researcher wherein he/she should determine the basic terms to be adhered to while searching for books and other similar information resources.

- **Select the right library tool**: Depending upon the scope of your research, you can resort to the appropriate library tools required for collecting the information for research. There is a wide range of tools offered by a library in modern times. These tools span from small almanacs and handbooks to the most comprehensive books and anthological volumes, and most obviously the computerized library catalogue, which is the result of information technology revolution.

Library Research Tools

Once the researcher has executed the activities involved in the research plan, he/she should start looking for the essential and relevant information. This involves exploring information through traditional and modern library research tools, which contain specific bits of information as well as voluminous records and theories. To be able to make full use of these tools, it is necessary for the researcher to become familiar with the applications of these specific library tools. The most common library research tools available in any library are as follows:

- **Library catalogue**: A library catalogue is an informative list of resources and materials available in the library. It comprises the name of books or journals along with the name of authors, subjects and publishing houses. It thus, informs the researcher what is available in the library. Usually, in the developed countries, such catalogues are stored as computerized databases, which use featured searches with headings like 'author,' 'title,' 'subject' and 'keywords.' However, in India, many government-funded educational libraries are still using the paper-oriented catalogue technique except for such private libraries like the British Council Library, American Library, Indian Institute of Technology Library, etc. It is, therefore, advisable for a researcher to refine his/her research subject to specific key words and search for the necessary information using these key words.
- **Almanacs**: An almanac is a chronological tabular publication that is published annually. Traditional almanacs, usually, contained information regarding weather forecasts, astronomical data and several other statistics like the rising and setting of sun, moon, eclipses etc. However, in the current times, almanacs have become all comprehensive and include statistical and explanatory information regarding happenings in the whole world. Topical

weather developments, historical events, factual information, etc., are the features of the present almanacs. A researcher can use these for quick grasping of facts of his research topic.

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- **Dictionaries**: Dictionaries are most often regarded as a superficial source of information as it is supposed to be performing the sole function of defining the meanings of words. However, contemporary editions of dictionaries are much innovative in their own way and explain innumerable terms in context of several usages of the specific term. As such, a researcher should seek factual information in the dictionary and also search for related phrases mentioned in the context of the word being searched to get a broader view of his/her topic of interest.
- **Encyclopaedia**: Encyclopaedia, in general, is a bulk informative volume containing a synopsis of the concerned subject, which is published in alphabetical order. Encyclopaedia is, in fact, an extension of the concept of dictionary wherein the words are described precisely. A background context, however, can make the reader get more acquainted with the research term and, therefore, it is always preferable to consult an encyclopaedia to get a better knowledge of the subject matter. This also helps the researcher to understand several jargons and terminologies related to his/her subject of research.
- **Bibliographies**: A bibliography usually comprises a list of reference materials mentioned by the researcher. This list gives the names of various sources that the researcher has resorted to, such as books and articles for research. The bibliographies are mentioned at the end of the article or research paper. It gives information regarding any particular topic that has been published together as a book. There are two types of bibliographies depending upon the information they provide. These two types can be stated and explained as follows:
  - o **Enumerative bibliography**: This is also known as compilative, reference or systematic bibliography. It gives a general idea of the relevant publications in a specific subject matter. The most common format to be used by the researcher while giving citations in such bibliography is as follows:
    - Author
    - Title
    - Publishing company
    - Publication date
  - o **Analytical bibliography**: This type is further classified into descriptive, historical and textual bibliographies. Usually, these are concerned with

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the physical attributes and contemporary importance of a book. They take into account the size, format and context in which the book was printed and published, etc. Therefore, such bibliographies are not very closely connected to any form of research.

Bibliographies, however, provide a good research tool to refer to for an effective exploring through the vast data available in a library.

- **Indexes**: Indexes, as is well known, are the alphabetical lists of authors' name and subjects containing the relevant page numbers where these topics and authors have been discussed or described in the book. In research, they facilitate searching through a number of journals simultaneously and thus provide considerable information at the start of the research process. Indexes cover a large variety of sources, ranging from books, periodicals, conference papers, reports, thesis and articles, etc.
- **Search engines**: Search engines refer to software that browse through the Internet for the queried information and provide sites, which contain the concerned information within a few seconds. They operate automatically and collect words available on a vast number of web pages. A researcher needs to understand and learn the technique of effective utilization of a search engine. He/She should also be aware regarding the evaluation of the results that the search engines provide. The most popular search engines used all over the world today are Google and Alta Vista.

It is evident from the above discussion that with technological inventions, the nature of library research has changed tremendously. It has extended its scope and deals with vast range of information simultaneously. The researcher today, therefore, needs to familiarize himself/herself with various jargons and terminologies to get a good grasp of the research tools. The description that follows includes the various words commonly used in library research.

Use of Library Resources

There are innumerable information materials available in a library. In general, the prime sources of information can be classified and explained in the context of research usability as follows:

- **Books**: Undoubtedly, books are the most significant and chief resource of information in any library. However, irrelevance can greatly hamper a book's usability for the researcher. It is, therefore, very essential for a researcher to examine whether the book he/she is referring is relevant to his/her research study or not. A researcher should also check for the authority of the book, i.e., whether the author is an expert in the field or a well-known publishing house has published the book. Checking for the contemporariness will also facilitate the researcher to remain up-to-date in conducting his/her research study.

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- **Journals**: Journals refer to a periodical collection of articles. They also include such sources like reports, bulletins or proceedings, published monthly by any organization or an institution. There are also certain scholarly journals, which are of great help to a researcher working in the field of humanities or social sciences. Usually, journals contain articles, which can offer thorough knowledge or up-to-date information regarding the subject matter of research.
- **Thesis**: In simple terms, thesis refers to a piece of research work conducted by an individual to qualify for a degree. Usually, libraries often hold copies of thesis, which have been submitted and approved for Ph.D. A researcher can browse through such thesis to get an idea of the layout and presentation options for his/her own thesis. While making use of such thesis, the researcher should remember that they are copyright protected materials and for quoting from a thesis, it is essential to take a prior written consent from the concerned author.
- **Manuscripts and archives**: These are unpublished, sometimes hand-written or typed original and primary sources of information. A study of these manuscripts gives the researcher an idea of the original study conducted in the past and thus guides him/her in conducting the research. Manuscripts can be used for citing examples to prove his/her points by referring to past occurrences and events. It is, however, absolutely important to preserve the integrity of such sources and, therefore, a researcher should repeat the original text exactly if required without any omissions, additions or corrections.

It is absolutely important for the researcher to check the relevance of the concerned materials while referring anything from the mentioned sources in his/her research study. Usually, there is a general tendency to simply use what comes first at hand. Secondly, one is bound to believe anything when it is in print. However, a good research is not the result of such quick and simple adaptations. A researcher should give plenty of time to conduct the research study. He/She should examine every available source of information to its fullest usable degree.

It is also necessary to check the accuracy, timeliness and depth of the content in the concerned source of information. Check out if the topic is being covered exhaustively by the book, or thesis or journal to which you have resorted. It is always advisable for the researcher to consider the target audience he/she is going to address and scrutinize. For example, a research that aims at conducting a study among the students of postgraduate courses should use refined and superior level of vocabulary. In that case, resorting to a book meant for high school students should be restricted till the extent of selecting basic ideas required for the research. However, it is obviously the researcher’s job to adapt his/her target audience and present the ideas in his/her own unique style.

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The researcher, while conducting a research, collects a large amount of data and stores them in the computer. However, it depends on the hardware and software capacity of the computer to store the information and data. The hardware and software capacity can be changed or managed as per the requirements of the organization.

14.5.2 Uses of Internet in Research

Before the evolution of the Internet, conducting a research work involved a set of encyclopaedias and a trip to library. However, now we live in an age where the information is easily accessible via computer using Internet. Today, information and data can be easily accessed with the help of the Internet. The Internet is the fastest developing and the largest repository of data. A researcher on the Internet can find information about any topic he/she desires. The Internet acts as a huge database of the content where a researcher can access an unlimited number of informative sources.

Research itself is a very wide term. It means a systematic enquiry of the facts. There are various common applications of Internet research. One such application of the Internet research includes the personal research that is undertaken in order to enquire about a particular subject such as news or health problems. Various other applications of the Internet research also include research undertaken by the students for academic projects and papers, and writers and journalists researching stories.

One of the advantages of conducting research using the Internet is that hundreds or thousands of pages can be found with some relation to the topic, within seconds, which is not possible if the same topic is to be searched from books or encyclopaedias. Moreover, the Internet also includes e-mail, online discussion forums and other communication facilities such as instant messaging and newsgroups that help the researchers have a direct access to the experts and other individuals with relevant knowledge and interests.

There are various tools such as Internet search engine and Internet guide that a researcher can use for collecting the information. A search engine is an online database of Internet resources. When the researcher poses a query about a particular topic, the search engine looks for the likely matches within the database and displays the relevant content accordingly. Unlike, a standard search engine, the information that is contained within an Internet guide is compiled and organized by the humans, not computer programmes. Encyclopaedia Britannica is an example of Internet guide that covers a vast category of different topics.

However, there is one disadvantage for the researchers in conducting a research with the help of the Internet. The disadvantage is that the majority of the content available on the Internet is self-submitted and there are few rules and

regulations that a researcher has to adhere with regard to what a researcher can publish and what he/she cannot. Moreover, the content on the Internet may sometimes be inaccurate and opinion based.

However, the Internet must not be disregarded as the major source of conducting research. It is one of the major sources of journals, books, general information and other relevant content. Therefore, we can say that the Internet is a very important source for the researchers in this modern age for the purpose of collecting information.

Check Your Progress

7. What is the importance of thesis in research?
8. Give an example of internet guides.

14.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Some of the international bodies which have provided well established and detailed ethical guidelines include the Social Research Association (SRA), the American Psychological Association (APA), the Council of American Survey Research Organizations (CASRO), the American Marketing Association (AMA), Business Marketing Association (BMA), etc.
2. The most significant and important ethical concern of a research study is the issue of trust and confidentiality.
3. The control of quality and privacy are important checks in a study.
4. The most important and vulnerable person in the research study is the respondent from whom the data is to be collected.
5. The benefit of a mutual written or unwritten contract is that there is no unpleasantness or legal confrontation on either side. Another advantages of this is that in case a point was not very clear, the issue gets clarified.
6. Professional creed refers to the overall conduct of the researcher, who has to be truthful during all phases of the study, whether in the conceptualization, conduction or presentation of the research study.
7. A researcher can browse through the prevailing thesis to get an idea of the layout and presentation options for his/her own thesis.
8. Unlike, a standard search engine, the information that is contained within an Internet guide is compiled and organized by the humans, not computer

programmes. Encyclopaedia Britannica is an example of Internet guide that covers a vast category of different topics.

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14.7 SUMMARY

- Ethics are extremely important in research and standard guidelines for this are available from different associations.
- The client must not use pressure to steer the results in the direction they want.
- The researcher has maximum responsibility in following a code to ensure quality of reporting, being transparent and yet maintain the privacy of both the client as well as the respondent.
- Utmost care must be taken at all times to protect the rights of the respondent.
- The researcher has to be absolutely transparent and objective while conducting and interpreting the research study results.
- A library research plan is a predefined activity that gives direction to your research. It is an act that involves evaluation that helps determine the subsequent activities to be followed by the researcher. As such, the research plan is a sequence of steps that the researcher should follow in order to get a comprehensible and reliable outline to adhere to.
- Once the researcher has executed the activities involved in the research plan, he/she should start looking for the essential and relevant information. This involves exploring information through traditional and modern library research tools, which contain specific bits of information as well as voluminous records and theories.
- Before the evolution of the Internet, conducting a research work involved a set of encyclopaedias and a trip to library. However, now we live in an age where the information is easily accessible via computer using Internet. Today, information and data can be easily accessed with the help of the Internet. The Internet is the fastest developing and the largest repository of data. A researcher on the Internet can find information about any topic he/she desires. The Internet acts as a huge database of the content where a researcher can access an unlimited number of informative sources.

14.8 KEY WORDS

- **BMA:** Business Marketing Association.
- **Quality control:** Maintaining the highest quality standards while conducting the research study

- **Research ethics:** A set of principles or guidelines that will assist the researcher in making difficult research decisions and in deciding which goals are most important in reconciling conflicting values.
- **Stakeholders of research:** Client, researcher and the respondents
- **Library research plan**: A library research plan is a predefined activity that gives direction to your research.
- **Library catalogue**: A library catalogue is an informative list of resources and materials available in the library. It comprises the name of the book or journal, along with the concerned author names and also includes subject names and the name of the relevant publishing house.
- **Search engines**: Search engines refer to software that browse through the Internet for the queried information and provide sites that contain the concerned information, within a few seconds.

14.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What are the three basic principles of professional ethics that any research must follow?
2. Who are the three significant stakeholders involved in any research?
3. What is study disclosure?
4. Write a note on library catalogues.
5. Explain the use of manuscripts and archives in research.

Long-Answer Questions

1. How can you follow an ethical path for conducting your research? Are there any guidelines available for this? Elaborate.
2. Does the client also need to maintain certain ethical standards? Explain.
3. What are the aspects that the researcher has to be careful about while conducting a study?
4. How do you follow an ethical practice while collecting information from the respondents?
5. Discuss the various library research tools available to today's researchers.
6. Explain the importance of the Internet in research.

14.10 FURTHER READINGS

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